CALFED

TECHNICAL REPORT
ENVIRONMENTAL CONSEQUENCES

WATER QUALITY

DRAFT

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CALFED
BAY-DELTA
PROGRAM

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LIST OF ACRONYMS

BMP	best management practice
CALFED	CALFED Bay-Delta Program
cfs	cubic foot per second
CFU	Colony Forming Unit
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
DBP	disinfection by-product
DICU	Delta Island Consumptive Use
DOC	dissolved organic carbon
DWR	California Department of Water Resources
EC	electrical conductivity
IEP	Interagency Ecological Program
km	kilometer
MAF	million acre-feet
mgd	million gallons per day
mg/L	milligrams per liter
M&I	municipal and industrial
MPN	Most Probable Number
MWQI	Municipal Water Quality Investigations
NA	Not applicable
nm	nanometer
NPDES	National Pollutant Discharge Elimination System
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
Reclamation	U.S. Bureau of Reclamation
RWQCB	Regional Water Quality Control Board
SFRWQCB	San Francisco Regional Water Quality Control Board
SWP	State Water Project
SWRCB	California State Water Resources Control Board
TAF	thousand acre-feet
TDS	total dissolved solids
THM	trihalomethane
TOC	total organic carbon
TSS	total suspended solids
WQCP	Water Quality Control Plan
μS/cm	microsiemens per centimeter
μmho/cm	micromho per centimeter(equivalent to μS/cm)
μg/L	micrograms per liter

WATER QUALITY

INTRODUCTION

This technical report discusses the impacts on water quality of implementing the CALFED Bay-Delta Program (CALFED).

Program actions may result in changes in the loadings of water quality constituents and parameters of concern to the Sacramento-San Joaquin Delta and contiguous water bodies from their tributaries, waste discharges, and the ocean. The magnitude, timing, and direction of instream and in-Delta flows also would be altered to various degrees, with consequent effects on water quality. The release and passage of adequate freshwater inflows into the Delta and the prevention of excessive or poorly timed diversions are essential management mechanisms for preventing excessive seawater intrusion, maintaining suitable salinity gradients, providing good water quality at locations of use, and assuring the continuation of other vital system functions.

The report also describes the methods of analysis used to identify these consequences and the criteria used to evaluate their significance. Because of the complexity of the subject matter and the large volume of data, all figures for this technical report are located in a separate section at the end of the report.

Specific parameters and conditions were selected for analysis that are important for defining the state of the estuary and the tributary rivers, and for identifying potential impacts. The selected water quality and hydrodynamic parameters are compared among alternatives under a variety of conditions, and potentially significant impacts and mitigation measures are discussed for each CALFED alternative and alternative variation.

Computer models were developed to help predict these changes and to identify the range of conditions under which the changes would be beneficial or adverse. The use of these models for impact assessment also is described in this report. Results and conclusions are limited by the degree to which alternatives have been defined for this programmatic-level assessment, by the predictive accuracy of the models, by the assumptions made for each run, and by the current knowledge about impact mechanisms.

The most general CALFED objective for water quality is to provide good water quality for all beneficial uses, which include maintenance of various important groups of aquatic biota and provision of suitable raw water supplies for domestic uses. Meeting this objective also requires reducing conflicts in water quality requirements among competing beneficial uses. The purpose of the programmatic impact assessment is to identify potential changes in water management conditions, both beneficial and adverse, under each CALFED alternative relative to both the No Action Alternative and existing conditions. Additionally, the programmatic impact assessment identifies differences among the alternatives and provides information to assist decisionmakers in selecting a CALFED preferred alternative.

Some of the program actions that could produce potentially significant water quality impacts include:

- Construction activities associated with the installation of storage and conveyance facilities, channel widening, and setting back levees;
- Converting land from agricultural uses to wetlands and other aquatic habitats;
- Reducing contaminant loads from mine

drainage, urban and industrial runoff, and wastewater treatment plant discharges;

- Relocating diversions and discharges;
- Changes in reservoir diversions, operations, releases, and diversions;
- Construction and operation of channel barriers;
- Changes in Delta outflows to San Francisco Bay, and water circulation, transport patterns, and magnitudes within the Delta; and
- Storing and transferring surface water and groundwater.

ASSESSMENT METHODS

Two methods were used to predict the effects of various actions on water quality. For programs common to all alternatives, data on water quality constituent emissions from various sources, current concentrations of contaminants in waterbodies, and the estimated effectiveness of controls were used to make semiquantitative assessments of water quality impacts.

The complexities of the storage and conveyance alternatives, and the environment they affect, are such that it was virtually impossible to quantitatively analyze other impacts of the individual alternatives without the use of numerical models. As in the Draft Environmental Consequences Technical Report for Surface Water, potential impacts on stream and conveyance flows outside the Delta, and on cha nnel flows within the Delta, from implementing CALFED alternatives were analyzed using the results of simulations performed by the California Department of Water Resources (DWR). These simulations were performed using DWRSIM (an operations planning model) and DWRDSM1 (the Bay-Delta hydrodynamic model), respectively.

DWRSIM was used to simulate the hydrology of the Sacramento River and San Joaquin River systems. DWRSIM converts hydrologic information into estimates of streamflows. All model runs were made under assumed 2020 conditions, consistent with the No Action Alternative, and included projections of water demands for that future level of development. Streamflow estimates were based on historical precipitation and flow records for 1976 to 1991. Exports at the Central Valley Project (CVP) and State Water Project (SWP) pumping plants were limited to diversions that maintained compliance with Delta water quality standards contained in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Quality Control Plan (WQCP) (California State Water Resources Control Board [SWRCB] 1995).

In addition to simulating the hydraulics of the Delta (the flows and water levels in the Delta), the DWRDSM1 model was used to project in-stream and Delta channel concentrations of salinity, dissolved organic carbon (DOC), and bromide, assuming the implementation of selected, representative alternatives at the 2020 level of development. Salinity, DOC, and bromide are key constituents of concern for protection of beneficial uses of Delta waters.

The DWR Modeling Support Branch modeled total dissolved solids (TDS) for six alternative configurations (1A, 1C, 2B, 2D, 2E, and 3E) that are considered most representative of the full range of alternatives under consideration (DWR 1997c). The reported value of TDS is the average over the last tidal cycle of each month and is referred to as "end of the month" salinity.

The modeling was conducted using the DWRSIM model for simulating system hydrology and the DWRDSM1 model for simulating hydraulics and TDS in the Delta. Key assumptions in the modeling of all alternatives included south-of-Delta demands projected to year 2020, in-Delta and Sacramento Valley demands corresponding to 1995, and hydrology based on historical precipitation and flow records for water years 1976 through 1991. System operations (SWP pumping) are adjusted in DWRSIM to comply with Water Quality Standards as described in the WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995). Detailed assumptions for the modeling are described in DWRSIM Benchmark Study 472B (CALFED 1997b). These modeling projections do not include the effects of additional north-of-Delta or south-of-Delta storage and therefore represent only the effects of conveyance features associated with each alternative variation on water quality.

Disinfection by-product (DBP) precursors are being modeled by DWR using the Delta Simulation Model DWRDSM1. This modeling is part of an effort to evaluate the effects of CALFED alternatives on DBP precursors and evaluate the water treatment costs to meet current and anticipated U.S. Environmental Protection Agency (EPA) regulations on DBPs. The modeling is being conducted for bromide, DOC, and ultraviolet absorbance at 254 nanometers (nms) (UV-254), an *in situ* measure of organic carbon. The model assumes that these elements are conservative. Model results were generated for water years 1985, 1986, and 1987. Details of the modeling approach and assumptions can be obtained from "Modeling DBP Precursor Transport," Draft Memorandum (DWR 1997b). The results from this preliminary modeling effort were used to identify general trends and the likely order-of-magnitude of effects.

The modeling runs completed to date simulate only the effects of conveyance improvements; they do not account for the effects of new storage facilities that are included in some alternative configurations. The effect of storage can be assessed only qualitatively. Detailed assumptions used in the modeling are described in various reports and memoranda published by DWR. Specific information about the DWRDSM1 CALFED modeling effort also can be found at http://www.delmod.water.ca.gov. and in progressive CALFED modeling status reports (CALFED, December 1, 1997). The methods and assumptions used to set up the models to accurately reflect the configuration and operation of the existing supply and conveyance system, and to reflect the modifications imposed on the existing system by the program alternatives, has been described in detail in these supporting reports and is not repeated here.

The modeling effort is a valuable tool, subject to continued refinement and improvement, but it cannot provide all of the information needed to analyze the impacts of the alternatives. Where the modeling results are incomplete or not applicable, impacts were estimated based on other available information and professional judgement. The use of other methods of analysis is documented, as needed, in this report.

Hydrodynamic and resultant water quality impacts of the alternatives on the Delta were evaluated based on in-Delta modifications and on changes in operations of the State Water Project (SWP) and Central Valley Project (CVP) that affect the Delta. Effects on monthly average flows, velocities, and stages in Delta channels were evaluated using DWRDSM1.

Salinities at specific Delta control points are a key to protection of dependent beneficial uses and compliance with water quality standards. Salinity as TDS was evaluated at up to six locations in the Delta Region: Contra Costa Canal intake (Rock Slough), North Bay Aqueduct Intake (Barker Slough), Clifton Court Forebay, Emmaton, Jersey Point, and Prisoners Point. Salinity standards are defined for five of these locations and compliance projections are used in DWRSIM to allocate water supplies. Salinity was evaluated by observing the magnitude and frequency of changes between alternatives. A significant adverse change in salinity is defined as a long-term, or substantial, increase in salinity.

Another key factor for maintenance of the health of the Bay-Delta system is the set of relationships among salinity concentrations, the salinity gradient, and the ecology of the estuary. During the dry season, saltwater from the Pacific Ocean moves into the Delta from the Bay; during the wet winter season, saltwater moves seaward, driven by the increased discharge of freshwater. The principal sources of freshwater inflow to the Bay-Delta are the Sacramento River and San Joaquin River. Between winter and summer, resultant salinities can vary by as much as 10 parts per thousand (ppt) in many parts of the system.

Delta outflow is the major factor influencing seasonal and yearly variations in salinity. These variations in turn affect the locations where aquatic species live within the Bay-Delta system. Most of the variations in the Bay are caused by changes in the magnitude and patterns of freshwater discharge from the Delta, and by the resultant mixing of freshwater with seawater. Peak spring Delta outflows are thought to be important for transporting water quality constituents of concern out of the Delta and otherwise maintaining the health of the Bay-Delta system.

Although much remains to be learned about the effects of salinity on estuarine habitats, the X2 (2,000 parts per million [ppm] isohaline) position is used as a parameter in the decision-making process to control freshwater outflows, resultant salinity gradient and position, and consequent ecological habitat characteristics and extent. In this analysis, the position of X2 was used to qualitatively assess potential impacts of CALFED alternatives on the Bay-Delta system.

The model runs provide a preliminary assessment of the magnitude of changes that would be expected for each alternative and configuration. The water quality effects of some configurations are expected to be similar to other configurations. In these cases, one set of modeling assumptions has been used to represent alternative configurations that would have similar water quality impacts. Differences between such configurations are discussed in qualitative terms.

SIGNIFICANCE CRITERIA

The significance of impacts may be determined by selecting thresholds at which the magnitude of projected changes in concentrations of constituents of concern are judged to be capable of producing harmful or beneficial effects on dependent uses. At the programmatic level, however, it is difficult to determine whether such thresholds will be exceeded. It is more feasible to identify ranges of possible impacts and benefits for each alternative and to subjectively evaluate the significance of these ranges relative to the No Action Alternative and existing conditions.

The potential significance of adverse impacts and beneficial effects was assessed with respect to the degree to which the results of the model studies and qualitative assessments indicate that various water quality constituents or parameters of concern could be adversely affected by program alternatives.

An adverse change in water quality is defined as a significant change in one or more constituents that could cause degradation of dependent beneficial uses or ecosystem habitats. Beneficial changes are those that could enhance water quality and dependent beneficial uses and ecosystem habitats. In some cases, changes in flow and resultant water quality could have both beneficial and adverse impacts. For example, export pumping from the south Delta may be considered to cause adverse water quality impacts if its magnitude induces increased ocean salinity intrusion into the Delta. However, the same export pumping may be considered to produce local water quality benefits if it improves local circulation, withdraws contaminated water, and prevents stagnation in south Delta channels.

For this report, preliminary assessments of significance were made based on the projected ranges in magnitude and extent of changes in the concentrations of constituents of concern that would result from proposed CALFED actions. Projected ranges of change were classified as either negligible, minor, or moderate. A moderate increase in concentration was considered potentially significant. However, the modeling conducted to date offers only an approximation of impacts at a few locations, and many of the water quality constituent assessments are qualitative. Thus, the preliminary determination of significance was largely subjective and depended heavily on the judgment of the technical specialists who prepared the report. The CALFED team responsible for water quality will review the information contained in this report to make final determinations of impact significance and will determine whether the predicted changes in concentrations of constituents and parameters of concern would significantly affect the most important beneficial uses, including protection and enhancement of fish and wildlife resources, and the suitability of Delta waters as a source of raw drinking water supply.

ENVIRONMENTAL CONSEQUENCES

Comparison of No Action Alternative to Existing Conditions

INTRODUCTION

This section describes the expected effects of the No Action Alternative, with its increased future population and associated water demand at the 2020 level of development. The effects are compared to existing conditions. Existing conditions are defined and described in the Draft Affected Environment Technical Report for Water Quality. The quantitative evaluations of the effects of the No Action Alternative are based on the results of computer modeling performed by DWR (see the "Assessment Methods" section of this report). The computer modeling studies are not yet complete and continue to be refined. For example, the modeling studies used as a basis for this assessment did not include Central Valley Project Improvement Act (CVPIA) flow targets. Future studies are expected to include the CVPIA flow targets as an assumption of the No Action Alternative.

The No Action Alternative assumes that the population of the Central Valley will grow from 4.6 million in 1997 to 7.2 million in 2020, as currently projected. This represents an increase of approximately 60%. Assuming that average density in future urban areas is the same as in existing areas, the acreage of land devoted to urban uses and the emission of pollutants in urban runoff also would increase by 60%. Water quality would deteriorate in response to increased pollutant emissions, with the most pronounced projected effects occurring near stormwater outfalls.

Under the No Action Alternative, the waters of the Bay-Delta system and its tributaries would be managed generally as they are today, but modified as necessary to comply with the CVPIA. Water storage or conveyance facilities currently under construction would be completed, but no new facilities would be built. Total annual water withdrawals from the Delta would increase from the current 5.9 to 6.9 million acre-feet (MAF) to 7.1 to 7.6 MAF in 2020, even assuming that moderate water use efficiency measures are implemented. This represents an increase of between 10% and 20%. Although wastewater treatment facilities would be expanded to meet the needs of the growing population, the levels of treatment provided are expected to remain at current levels. Levees would be maintained according to current practices, but no major rehabilitation would be undertaken. Non-project levees would continue to be maintained under SB-34 and SB-1390.

The same modeling assumptions were used to represent conditions under existing conditions as under the No Action Alternative. Future refinements to the Delta hydrodynamic and water quality modeling efforts are planned that would differentiate between existing conditions and the No Action Alternative. However, at present, no quantitative model outputs are available for existing conditions to permit consistent comparison of the two scenarios.

To avoid a complete gap in the analysis, model predictions were compared to historical data for the No Action Alternative only. Figures 1 through 3 show model predictions of TDS at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show averaged model predictions of water quality for the No Action Alternative (and Alternative IC, which can be ignored for now). Historical data depicting average concentrations for series of representative "wet" and "critically dry" years also are plotted for comparison. The specific years within each water-year type that are shown on the figures are based on the Four-River Decision 1485 Water-Year Classification Index. The mean monthly measured data for wet and critical years were obtained from DWR's Municipal Water Quality Investigations (MWQI) Program or the Interagency Ecological Program (IEP).

As shown in the figures, salinity exhibits a seasonal pattern, with lower concentrations generally occurring from February through June. During these months, Delta outflow is maintained (primarily by adjusting SWP pumping and releases from storage) to meet the 2.64 electrical conductivity (EC) isohaline criterion (also known as X2) at Chipps Island and Port Chicago. Higher Delta outflows reduce TDS concentrations, even during critically dry years, to concentrations around 200 milligrams per liter (mg/L), which are comparable to wet-year historical data. During late fall and winter, TDS concentrations are higher and generally peak around December at 500 to 600 mg/L during critically dry years, and 300 to 400 mg/L during wet years. This effect primarily is due to lower Delta outflows during this period, caused by a combination of lower Delta inflow and increased SWP pumping. The predicted concentrations during late fall and winter tend to be higher than measured at Rock Slough (Figure 1) but comparable to measured data at Clifton Court (Figure 2). Predicted TDS concentrations at the North Bay Aqueduct intake at Barker Slough are relatively low (less than 200 mg/L) and are not very different from historical data (Figure 3). Model predictions and observed data at the Tracy Pumping Plant Intake are not shown because the results are similar to those at Clifton Court.

DWR's service contract with the state water contractors requires that maximum monthly mean concentrations of exported water not exceed 440 mg/L. The predicted values and historical data for the average of the critically dry water-year types exceed this value in December and January (Figure 2). For the 15 years of hydrologic record (180 months) that encompass a variety of water-year types, predicted TDS concentrations exceed 440 mg/L in 23 months or about 13% of all months. These exceedances were predicted to occur from September through February.

Delta channel flows and exports (primarily SWP) were adjusted in the model to manage salinity intrusion to meet the regulatory X2 requirements and other water quality and flow requirements in the Bay-Delta WQCP (SWRCB 1995) to the extent possible (Figure 4).

Natural Organic Matter

DBP precursors were modeled by DWR using DWRDSM1. This modeling is part of an effort to evaluate the effects of CALFED alternatives on DBP precursors and evaluate the water treatment costs to meet current and anticipated EPA regulations on DBPs. The modeling was conducted for bromide, DOC, and ultraviolet absorbance at 254 nm (UV-254), an *in situ* measure of organic carbon. The model assumes that these elements are conservative. Model results were generated for water years 1985, 1986, and 1987. Details of the modeling approach and assumptions can be obtained from

"Modeling DBP Precursor Transport," Draft Memorandum (DWR 1997b). The results from this preliminary modeling effort are presented to identify general trends and the likely order-of-magnitude of effects.

Figures 5 through 7 show No Action Alternative model predictions of DOC at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show model predictions for two extreme water-year types: wet (water year 1986) and critically dry (water year 1987). Also shown for reference are the mean monthly measured data for wet and critical years (selected based on data availability) obtained from DWR's MWQI program or the IEP.

The figures show that predicted DOC concentrations (and measured DOC) for this alternative exhibit a strong seasonal variation, with peak DOC levels occurring in January and February. Maximum values of DOC are highest at the North Bay Aqueduct (15 to 17 mg/L), moderate at the Contra Costa Canal Intake (7 to 9 mg/L), and lowest at Clifton Court (5 to 6 mg/L). Predicted and measured DOC concentrations also tend to be higher during wet years compared to critically dry years. These trends generally are consistent with DOC measurements from agricultural return flows. At Contra Costa Canal Intake and Clifton Court Forebay, predicted DOC concentrations are comparable to measured data, whereas at the North Bay Aqueduct, predicted concentrations are somewhat higher than observed in November through March.

BROMIDE

Figures 8 through 10 show No Action Alternative model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show model predictions for two extreme water-year types: wet (water year 1986) and critically dry (water year 1987).

At the Contra Costa Canal Intake (Figure 8) and Clifton Court Forebay (Figure 9), predicted bromide concentrations exhibit a seasonal pattern, with low concentrations (generally less than 0.2 mg/L) from February through June and peak values around 1 mg/L in November through January. Concentrations also are higher during critically dry years compared with wet years. This pattern is similar to that for TDS and the direction of the gradient indicates that the major source of bromide is seawater. Predicted concentrations at these two locations tend to be higher than measured during fall and winter. At the North Bay Aqueduct intake at Barker Slough, predicted and measured concentrations are generally less than 0.2 mg/L, indicating that the effects of salinity intrusion are limited at this location.

FLOWS AND VELOCITIES

An understanding of anticipated hydrodynamic changes provides a basis for projecting dependent water quality impacts under No Action Alternative conditions that include increased future demands. The following is a qualitative summary of projected changes relative to existing conditions. (Refer to the Draft Environmental Consequences Technical Report for Surface Water for more detailed information.)

Additional pumping from the south Delta is projected under the No Action Alternative because of increased 2020 demands. Adverse effects of increased exports from the Delta probably would be mitigated somewhat by increased inflows to the Delta (mostly from increased releases from upstream storage on the Sacramento River). However, many problems would not be solvable without facilities. These would include increased flows and velocities through the interior Delta toward the project export pumps.

The subtle effects of this increased demand on Delta hydrodynamics and water quality under 2020 conditions cannot be evaluated without the aid of computer modeling. Modeling of existing conditions is not complete.

NET DELTA OUTFLOW

DWRSIM modeling was used to evaluate differences in net Delta outflows between the No Action Alternative and existing conditions. For the No Action Alternative, the average net annual Delta outflow was 20,000 cfs, and ranged from 5,600 cfs to 92,000 cfs. In comparison, the average net annual Delta outflow for existing conditions was 20,700 cfs, ranging from 5,500 cfs to 94,300 cfs. Simulated monthly average net outflows for the No Action Alternative were similar to outflows for existing conditions. These represent minor changes in both the wet- and dry-year average net outflows.

The distribution of differences indicates that, most of the time, flows produced by the No Action Alternative would not be much different from flows under existing conditions. The greatest differences are projected to occur during June, when half of the compared flow values differ by between 30% and 40%. These results suggest that the No Action Alternative may have a significant adverse effect on June Delta outflows and dependent water quality constituents, relative to existing conditions.

CENTRAL DELTA FLOWS

As discussed above, increased export pumping in the south Delta combined with increased inflows from the Sacramento River due to releases from storage during low runoff years likely would increase cross-Delta flows toward the export pumps under the No Action Alternative. Delta hydrodynamic modeling has not been completed, and no quantitative estimates of the impacts of the No Action Alternative on Central Delta flows and resultant water quality effects are available.

SALINITY

Under the No Action Alternative, increased pumping from the south Delta relative to existing conditions probably would increase the potential for low-quality saline water to intrude from the west Delta toward the export pumps. The difference is expected to be small most of the time because south Delta pumping is limited by the capacity of the H. O. Banks Pumping Plant and by the constraints on the X2 position set by the Bay-Delta WQCP. In some months, particularly June, decreased net Delta outflow during low-flow periods, combined with high summer export demand, would increase the potential for adverse impacts. It is estimated that the salinity of water at the CVP and SWP pumps could increase by 10 to 20% or more during dry periods, a significant adverse impact. Bromide, a carcinogenic DBP precursor originating primarily from seawater, also is projected to increase significantly in concentration in the south Delta and exports.

MASS FATE OF CONSTITUENTS

Because computer simulations comparing particle transport under the No Action Alternative and existing conditions have not been completed, quantitative estimates of the impacts of the No Action Alternative on particulate and dissolved mass fates are not available. Based on hydrologic reasoning, the increased demand and consequent increased export pumping under the No Action Alternative should extend the influence of pumping further from the export pumps than under existing conditions. This would generally increase the proportion of dissolved and particulate mass entering the Delta that ultimately is entrained at the pumps.

OTHER WATER QUALITY IMPACTS

Because very little construction would occur under the No Action Alternative, few construction-related impacts on water quality are anticipated.

Overall water quality in the Delta would gradually deteriorate, however, between the present and 2020 as water diversions from the Delta, and urban wastewater and stormwater pollutant load mass emissions in the Central Valley, increase. The greatest effects would be felt in the south Delta and the project export pumps during dry and critical years. By 2020, water diversions are projected to increase by an average of 15%, and pollutant loads from municipal wastewater treatment plants and urban runoff would increase by approximately 60%. The overall water quality degradation caused by these factors is considered a significant adverse impact. Declining water quality in the Delta could cause cities and agricultural users to seek alternative sources of water. Development of other sources may adversely affect surface water or groundwater resources at other locations.

Levees would continue to deteriorate under the No Action Alternative, increasing the risk of catastrophic failures. Depending on the extent of potential flooding caused by levee failures, water quality at the CVP and SWP pumps and other water supply intakes would be degraded. In extreme cases, Delta waters could be so severely contaminated, and resistant to available flushing measures (imposed by limited availability of stored water, for example), that they could remain unusable for municipal and agricultural supplies for months or years. This would impose a severe crisis on human and environmental uses of the water in terms of public health, agricultural and industrial production, environmental resources, and the economy.

Comparison of CALFED Alternatives to No Action Alternative

DELTA REGION
ALL ALTERNATIVES

Ecosystem Restoration Program

The Ecosystem Restoration Program consists of actions designed to improve the quality and increase the extent of habitat for aquatic and terrestrial species in the Delta Region. Habitat improvements are intended to support sustainable populations of diverse and valuable plant and animal species.

Table 1 shows the actions proposed for the Delta Region. An initial screening was conducted to divide actions into two categories: those with minimal impacts on water quality and those with potentially significant impacts. Actions were judged to result in minimal impacts on water quality if they would not change the emission rate of pollutants or the concentration of pollutants in waterbodies, or if the changes produced clearly were negligible.

Restore Tidal Perennial Aquatic Habitat and Tidal Emergent Wetlands

The acreage of open-water aquatic habitat and tidal emergent wetlands would be increased by constructing setback levees, flooding islands, and connecting dead-end sloughs to Delta channels. Between 33,000 and 45,000 acres of agricultural land would be converted to aquatic habitat. Most aquatic habitat would consist of shallow open water with emergent vegetation around its margins.

Creating aquatic habitat would involve construction activities, principally removing sections of existing levee and constructing new levees. Flooding islands and reconnecting

Action	Magnitude	Potentially Significant Impacts on Water Quality
Restore tidal perennial aquatic habitat, and tidal emergent wetlands	33,000 to 45,000 acres	Yes
Restore tidally influenced freshwater marsh	20,000 to 25,000 acres	Yes
Restore tidally influenced channels and distributary sloughs	150 to 250 miles	Yes
Restore shallow-water habitat	7,000 acres	Yes
Restore shoals	500 acres	No
Create deep open-water areas within restored freshwater emergent wetland areas	500 acres	No
Create shallow open-water areas within restored freshwater emergent wetland areas	1,500 to 2,000 acres	No
Restore seasonal wetlands	34,000 acres	Yes
Restore riparian habitat	75 to 220 miles, 700 to 8,000 acres	Yes
Protect additional existing riparian woodlands	500 acres	No
Restore non-tidal emergent wetlands	15,000 acres	Yes
Restore channel islands	200 to 800 acres	No
Reduce water temperatures in Mokelumne, Calaveras, and Cosumnes rivers		Yes

Table 1. Ecosystem Restoration Program Actions for the Delta Region

dead-end sloughs would be accomplished by removing levees. It is expected that only short sections of levee would be removed to initiate flow. The remaining portions of the levees would be abandoned and allowed to deteriorate and eventually disappear. Water turbidity and suspended solids content would increase locally during levee removal. Minor increases in the nutrient and organic carbon content of water also may occur. Contaminants presently immobilized in the soil in the levees could be resuspended and dissolved during levee removal.

Some of the aquatic habitat would be created by constructing new levees behind the existing levees. When new levees were in place, the existing levees would be breached and allowed to gradually erode. The impacts of levee construction would depend on the method of construction and the nature of the materials used. In most cases, material would have to be imported for levee construction. Possible sources of material could include dredging materials from the Delta and the Bay Area. Because the source of material is uncertain, impacts associated with its excavation at the source are not discussed here.

Levee construction methods could vary. In most cases, levee construction materials would arrive at the site by barge. Materials would be unloaded by clamshell and put in place using earth-moving equipment. If the water content of the materials is high, they would be pumped into place. In some cases where channel dredging and levee construction occur in the same location, materials would be pumped into place using a suction dredge.

Because levees would be constructed in dry conditions rather than in Delta channels, adverse effects on water quality would be relatively minor. If materials with a high water content were used to construct the levees, any excess water would be directed to evaporation ponds rather than being discharged to Delta channels. The new levees would be compacted, armored if necessary, and seeded. Minor and localized increases in water turbidity could be expected when the new levees were first exposed to water. Depending on the source of the construction materials, minor and localized increases in water salinity and boron content could occur. When water first enters the area behind the old levees, nutrients may be released that could cause algae blooms.

Much of the agricultural land on Delta islands and bordering Delta channels is at an elevation below that of the adjacent waterways and is separated from the waterways by levees. Excess runoff and irrigation water drains from fields to perimeter ditches, which flow to sumps adjacent to the levees. Runoff and agricultural drainage water is pumped over the levees and into Delta channels. According to estimates developed by DWR using the Delta Island Consumptive Use (DICU), about 1 MAF of drainage water is returned to Delta channels from individual drains (DWR 1995). Most drainage is discharged to the channels during two periods: in June and July, when irrigation is at a maximum, and from November to January, when fields are flooded to leach salts from the soils.

Converting agricultural land to aquatic habitat would alter the emission rate of various substances to the San Joaquin River and its tributaries. Discharges from agricultural lands contain salts, organic carbon, nutrients, microbes, and traces of pesticides. After implementation of this action, the created aquatic habitat would continue to emit various substances, but their types and quantities would be different. Changes in emissions of metals and trace elements are expected to be negligible and are not discussed further. The changes could affect regional water quality because this restoration involves a 6 to 8% reduction in agricultural acreage in the Delta.

Natural Organic Matter

Agricultural drainage water in the Delta is relatively rich in natural organic matter. The organic matter is in both dissolved and particulate form and probably is attributable to dissolution and wash-off of organic matter from soils, particularly the peat soils prevalent in the Delta, crop residues, and aquatic plants in drainage channels. (The peat soils in the Delta have an organic carbon content of over 50%.)

Table 2 shows some of the characteristics of typical Delta drainage water, including its natural organic matter content measured in terms of DOC concentration. Ongoing studies by DWR have demonstrated that agricultural drainage discharges are the most important source of organic carbon emission in the Delta.

Construction would have negligible effects on elements of concern other than turbidity and suspended solids content. Dredged materials may contain low concentrations of various toxic substances. In most cases the new levees would be built in dry conditions; therefore, these substances would not be released into the aquatic environment during construction. However, there is potential for long-term leaching of toxic substances from new levees. Conversion of agricultural cropland on Delta islands to aquatic habitat would alter the emission rate of organic carbon to Delta waters. The magnitude and direction of the change are a matter of debate among technical specialists. Any change is important because it affects the cost of water treatment if Delta water is used as a source of drinking water. Certain components of natural organic matter in raw water, including humic and fulvic acids, react with disinfectants to form trihalomethanes (THMs) and other potentially harmful substances in finished drinking water. Because of its importance to municipal water purveyors, natural organic matter and potential changes in its emission into

Parameter	Unit	Webb Tract	Jones Tract	Rindge Tract
Electroconductivity	μS/cm	1,036	730	954
Chloride	mg/L	160	115	161
Bromide	mg/L	0.58	0.31	0.70
Dissolved organic carbon	mg/L	25.1	11.3	21.4
Trihalomethane formation potential	μg/L	2,150	1,287	1,963
Nitrate	mg/L	13.7	8.1	5.8

NOTES:

μS/cm = Microsiemens per centimeter.
μg/L = Micrograms per liter.

SOURCE:
DWR MWQI 1986-1991.

Table 2. Delta Island Drainage Water Quality

Delta waters are discussed in detail in the following paragraphs.

Two analytical tests commonly are used to measure the organic carbon content of water samples. The total organic carbon (TOC) test is made on a "whole" water sample and provides a measure of total particulate and DOC. The DOC test is made on a sample after passage through a 0.45-micron filter and generally is considered to provide a measure of DOC (the DOC test also measures organic carbon in the form of particles smaller than most bacteria). When applied to relatively unpolluted natural waters, the tests effectively measure natural organic matter because the concentrations of synthetic organic chemicals in natural waters are insignificant relative to concentrations of natural organics.

In Delta channel waters, little difference exists between the concentrations of TOC and DOC because most organic carbon is present in the dissolved form. DWR collects mostly DOC data in its MWQI program because DOC is considered a more reliable indicator of the potential to form DBPs during water treatment. All municipal drinking water plants that are supplied with raw water from the Delta employ filtration as a step in the treatment process prior to disinfection.

No data are available that provide a definitive conclusion about the change in DOC emission that might occur if irrigated agricultural cropland is converted to aquatic habitat. Various studies are under way that would increase understanding of the mechanisms involved in the interaction between organic soils and water, but they were not completed in time to provide information for this report. Several conceptual models have been proposed. Some postulate that current agricultural practices are very efficient in extracting DOC from Delta soils and that converting the land to aquatic habitat likely would decrease the efficiency of the process.

Delta islands typically are cultivated early in the year prior to planting. Cultivation increases the rate of soil oxidation. Earlier studies have shown that oxidized soils dissolve into the applied water, increasing the TOC content of drainage waters (Deveral et al. 199-). Data collected by DWR show that the organic carbon content of runoff waters from Delta croplands is at a maximum early in the year and declines thereafter. This indicates a pattern of seasonal build up and cultivation-promoted flushing of carbon from the soils. Permanently flooding Delta islands to form shallow-water aquatic habitat is unlikely to reproduce this pattern. Although waters would be in contact with soils for a longer period of time than under current conditions, the soil surface would not be disturbed, and conditions at the bottom of the water column probably would not promote rapid oxidation of soil. After several years, a layer of silt would cover the peat soils, and the dissolution of organic carbon would be further reduced.

A second conceptual model is based on the idea that keeping Delta waters in permanent contact with peat soils would increase the opportunity for dissolution of organic carbon compared to the current condition, where soils are in contact with water for only 6 or 7 months. Supporters of this conceptual model refer to the "tea bag effect" to illustrate that the longer water is in contact with organic matter, the greater the amount that would be dissolved.

As noted earlier, an average of 1 MAF per year of drainage water is discharged from Delta islands to Delta channels, with an average DOC content of 18.8 mg/L. Estimates of the mean annual DOC load vary depending on the island and the water year type. The annual DOC emission in agricultural drainage is 64 pounds per acre per year (refer to the Draft Affected Environment Technical Report for Water Quality). The 45,000 acres of agricultural land that would be converted to wetland habitat under this action currently emit an estimated 1,500 tons of DOC, or approximately 8% of the total DOC emission.

DOC concentrations at the Banks Delta Pumping Plant currently average 4 mg/L. Although the effects of restoring aquatic habitat and wetlands on DOC levels cannot be accurately predicted, some sense of the scale of potential effects can be obtained. Because current agricultural practices are considered quite efficient in dissolving DOC from soils, it is unlikely that conversion to habitat would more than double DOC emissions from the current condition. If DOC loads from the affected acreage doubled or were reduced by half, DOC concentrations at the Banks Pumping Plant would be expected to increase by 0.3 mg/L, or be reduced by 0.15 mg/L.

Although natural organic matter in water reduces its suitability as a drinking water source, it is an essential part of the aquatic ecosystem. Much of the organic carbon in natural waters is in the form of living organisms and their waste products. Carbon cycles through the food web as organisms grow, die, and are used as food by other organisms. Some of the actions contained in the Ecosystem Restoration Program would increase ecological productivity by increasing the availability of organic carbon.

Pesticides

Generally, pesticides are applied to Delta crops in spring and summer, and to orchards and alfalfa fields in winter and early spring. DWR monitored 30 pesticides in three Delta agricultural drains between 1983 and 1987, during the summer application period. Molinate, a rice herbicide, was the most frequently detected pesticide. Atrazine, bentazon, and molinate are used to control annual grasses and broad-leaved weeds for vine, fruit, and vegetable crops in the Delta.

Application of dormant sprays to orchards and weevil control insecticides to alfalfa fields contributes pesticide residues to Delta receiving waters in winter and early spring. A bioassay study was conducted by the Central Valley Regional Water Quality Control Board (CVRWQCB) in winter 1992 to assess the toxicity of orchard runoff (Foe and Sheipline 1993). Six pesticides were detected: diazinon, diuron, methadathion, bromocil, propham, and chlorpyrifos. Four pesticides were detected in samples collected to assess the toxicity of runoff from alfalfa fields: diazinon, diuron, carbofuran, and chlorpyrifos (Foe and Sheipline

1993).

Converting agricultural lands to aquatic habitat would eliminate the use of pesticides on the lands subject to this action. Pesticide emissions in drainage water could be reduced by 6 to 8% in the Delta Region.

Salts

Approximately 70% of the surface area of the Delta is devoted to irrigated agriculture (DWR 1995). Irrigation water is drawn from Delta channels and applied to cropland. When water is applied to agricultural land, some evaporates, some is used by crops, some runs off the surface of the land, and some percolates into the ground. Farmers must apply sufficient water to the land to flush the salts contained in the applied water out of the superficial soil layers. To do otherwise would allow salt to build up in the soil, with an adverse effect on crop yields or the type of crops that could be cultivated. In the Delta, salt that builds up in agricultural land in the irrigation season is flushed out in winter.

Little runoff of applied water occurs in the Delta; most of the water not evaporated or used by plants percolates into the ground and is drained to ditches at the perimeter of the fields, where it is pumped back into the Delta channels. The volume of drainage water is estimated to be 25 to 50% of the volume of the applied water. It is further estimated that the average salt content of drainage water is two to four times greater than that of the applied water (DWR 1993).

Large volumes of water with a relatively low salt content are diverted from Delta channels to irrigate cropland. After agricultural use, considerably smaller volumes of water with a higher salt content are returned to the channels. Because salts cannot be allowed to accumulate in soils over time, the salt load in the applied water and the discharged drainage water are approximately the same; therefore, irrigated agriculture is not usually a net emitter of salts to Delta waters on an annual basis. Salt may be deposited in soils in summer but flushed out again in winter.

If agricultural land was converted to shallow-water aquatic habitat, cropland would be replaced by open water with a fringe of emergent wetlands. Like agricultural lands, the created aquatic habitat would neither take up nor emit salts. Thus, the change in land use would have no effect on the emission of salts but would result in increased salt concentrations in Delta channels.

The evaporation rate from open water would be greater than the evapotranspiration rate from the corresponding acreage of agricultural land. The estimated evapotranspiration rate for open water in the Delta is 55.4 inches per year. The corresponding values for irrigated lands in the Delta uplands and lowlands are 35.9 and 31.2 inches, respectively (Jones & Stokes Associates 1995). The overall effect of conversion of land from irrigated agriculture to aquatic habitat in Delta agricultural drainage would be to reduce channel flow and increase salt concentration.

There is a seasonal component to the effects of land conversion on salt concentrations. As noted earlier, irrigators may allow salt to accumulate in the soil during the growing season, flushing it out in the winter non-growing season. Accordingly, in summer, more salt enters the fields with irrigation water than leaves with tailwater. When agricultural fields are converted to open water or wetlands, this artificial seasonal storage of salt would no longer occur. As a result, the overall annual increase in salt concentration attributable to land conversion would be overlain by a seasonal change. Salt concentrations would increase in summer and decrease in winter compared to existing conditions.

Nutrients

The principal nutrient in agricultural drainage water is nitrate. Phosphorus tends to become bound up in the soil, and ammonia is converted to nitrate by nitrifying bacteria in the soil.

Nitrate levels in agricultural drainage water are high. Concentrations are 25 to 50 times higher than in typical uncontaminated surface waters. Almost all the nitrate is attributable to nitrogen fertilizers applied to cropland.

Conversion of agricultural land to aquatic habitat would reduce nitrate emission. Plants in the newly created aquatic habitat would use nutrients drawn from water and sediments during the growth season, and release them in the form of organic nitrogen as plants die and decay. Unlike agricultural land, the aquatic habitat would not be a large net exporter of nitrogen.

Restore Tidally Influenced Freshwater Marsh

The acreage of tidally influenced freshwater marsh would be increased by constructing setback levees and flooding islands and island peninsulas. Between 20,000 and 25,000 acres of agricultural land would be converted to marsh. Most of the habitat would consist of emergent freshwater marsh that is subject to water surface elevation changes produced by the tide but rarely, if ever, becomes brackish.

Creating freshwater marsh would involve similar activities and result in impacts similar to those described for restoring tidal perennial aquatic habitat and tidal wetlands.

In parts of the Delta, agricultural lands are many feet below the water surface in the adjacent channels. If these areas were simply flooded they would, at least initially, be transformed into open water rather than freshwater marsh. To provide a substrate for marsh vegetation at a suitable elevation, the surface of the land would need to be built up. Imported fill, probably dredge materials, would be used for this purpose. Several construction scenarios are possible. The setback levee likely would be constructed first. Dredge materials could be delivered by barge to the site, lifted over the original levee, placed between the original and the setback levee, and graded to the required level using earth-moving equipment. If the dredge materials have a high moisture content, they could be pumped into place between the levees. In either case, placement of the material would occur in isolation from water in the Delta channels. Water turbidity would not be affected during construction. Turbidity would increase locally when the outer levee was breached.

An alternate construction method involves breaching the original levee when the setback levee is complete and dropping dredge materials directly into place from barges. Significant increases in local water turbidity would be expected if this construction method was used, although the movement of suspended material could be limited by silt curtains or temporary cofferdams.

Assuming peat soils could be covered by fill materials, construction would have negligible effects on elements of concern other than turbidity and suspended solids content. Dredged materials may contain low concentrations of various toxic substances. Levee construction in dry conditions would not usually release these substances to the aquatic environment, although in some cases dredge materials exposed to air may oxidize and cause heavy metals to dissolve when they come into contact with water. Placement of dredge materials directly into open water would likely release any toxicants present into the water column.

This action would convert agricultural lands on Delta islands and bordering Delta channels to freshwater marsh. The agricultural lands emit various substances that are discharged to Delta channels. After implementation of this action, the created marsh habitat would continue to emit various substances, but their types and quantities would be different. Emissions of metals, trace elements, and microbes are expected to be negligible and are not discussed further. The changes could affect regional water quality because restoring tidally influenced freshwater marsh in the Delta Region would reduce agricultural acreage by 4 to 5%.

Natural Organic Matter

Converting land from agriculture to freshwater marsh would change the rate of DOC emission in a manner similar to the conversion to tidal perennial aquatic habitat described earlier. As discussed previously, considerable uncertainty exists about the nature and magnitude of the change. For this analysis, it was assumed that converting agricultural land to wetlands could increase or decrease DOC emissions by up to 65%.

The annual DOC emission in agricultural drainage is about 17,000 tons, or 64 pounds per acre. If 25,000 acres of agricultural land were converted to wetland, the current annual DOC emission rate of 800 tons would increase to 1,320 tons or decrease to 480 tons. After restoring tidally influenced freshwater marsh, the total annual DOC mass emission from Delta islands would be 17,520 tons (a 3% increase from the current condition) or 16,680 tons (a 3% decrease).

Pesticides

Various pesticides are used on agricultural lands in the Delta. Conversion of agricultural lands to freshwater marsh would eliminate the use of pesticides on the lands subject to this action; therefore, the discharge of pesticide-containing agricultural drainage water would be somewhat reduced (see discussion under "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands").

Salts

The overall effect of converting land from irrigated agriculture to freshwater marsh would be similar to that described above for "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands." Evapotranspiration rates would increase, and the salt content of waters would increase correspondingly.

Nutrients

The principal nutrient in agricultural drainage water is nitrate. Almost all the nitrate is attributable to nitrogen fertilizers applied to cropland. Conversion of agricultural land to freshwater marsh would reduce nitrate emission. Plants in the newly created aquatic habitat would use nutrients during the growth season and release them in the form of organic nitrogen as plants die and decay. Unlike agricultural land, the aquatic habitat would not be a large net exporter of nitrogen.

Restore Tidally Influenced Channels and Distributary Sloughs

A system of channels and sloughs would be constructed in the Yolo Bypass and in the Cache and Putah Creek sinks, and connected to larger Delta channels. In some cases, existing channels would be dredged and widened. The new and expanded waterways would re-create a network of tidally influenced natural channels that existed before the land was drained for agricultural use. Between 150 and 200 miles of channel would be created. For analytical purposes, it was assumed that 70% of the land needed to construct channels currently is used for agriculture.

Channels and sloughs would be created by dredging existing channels and excavating new channels in agricultural lands. Effects of construction activities on water quality would depend on the construction methods used. New channels would be constructed in dry conditions using earth-moving equipment. No discharge of contaminants would occur during construction, but some increases in water turbidity would occur when new channels were connected to existing channels and tidal flow was initiated. Enlargement of existing channels also often would be undertaken in dry conditions, as the channels are isolated from tidal flow and are dry in summer. Excavation in channels containing water would result in localized turbidity increases, but the extent of the adverse effects could be limited by excavating behind cofferdams and diverting flow around excavations. The barge-mounted dredgers used in the larger channels would be a source of increased turbidity. Because sediments in the Cache Creek watershed contain mercury, there is some risk that disturbance of sediments could mobilize this toxic metal.

Restore Shallow-Water Habitat

The acreage of shallow-water aquatic habitat would be increased by constructing setback levees and flooding islands. Approximately 7,000 acres of agricultural land would be converted to aquatic habitat. Aquatic habitat would consist of shallow open water with emergent vegetation around its margins.

Impacts associated with creation of aquatic habitat are discussed above for "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands." Only about 1% of agricultural land in the Delta would be converted to shallow-water habitat.

Natural Organic Matter

Converting land from agriculture to shallow-water habitat would change the rate of DOC emission in a manner similar to the conversion to tidal perennial aquatic habitat described under "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands." This action would increase or decrease DOC emissions from Delta islands by less than 1%.

Pesticides

Various pesticides are applied to agricultural lands in the Delta. Conversion of agricultural lands to shallow water habitat would eliminate the use of pesticides on the lands subject to this action; therefore, the discharge of pesticides contained in agricultural drainage water would be slightly reduced (see discussion under "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands").

Salts

The overall effect of conversion of land from irrigated agriculture to shallow water would be similar to that described above for "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands." Evapotranspiration rates would increase, and the salt content of waters would increase correspondingly.

Nutrients

Refer to the discussion for "Restore Tidally Influenced Freshwater Marsh."

Restore and Enhance Midchannel Islands and Shoals

This action would protect and expand midchannel islands and shoals that serve as refuges for terrestrial and aquatic species. Dredging would be restricted to prevent diminution of existing shoals and islands, and fill would be placed to expand them. Between 200 and 800 acres of islands and shoals would be restored or created. Most land consumed for this purpose currently is used for agriculture.

This action would be implemented in conjunction with restoring tidally influenced freshwater marsh. In most cases, Delta channels are currently too narrow to accommodate new shoals and islands. Many channels would be broadened by construction of setback levees and abandonment of existing levees. New shoals or islands could be created by adding material at the toe of existing levees.

Shoals and islands would be constructed by placing dredged materials or possibly excess fill material produced when restoring tidally influenced channels and distributary sloughs. Placement of materials in moving water would increase local turbidity. If dredged materials were used for construction, some toxic materials could be released.

Restore Seasonal Wetlands

The acreage of seasonal wetlands would be increased by flooding agricultural lands for several months in winter and early spring. Small berms and other water control structures would be built to temporarily retain water in shallow basins. The berms may be temporary or permanent. Water primarily would be supplied by rainfall but may be obtained from Delta channels. Approximately 34,000 acres of agricultural lands would be used as seasonal wetlands. Crops would be grown after the land was drained in early spring.

Creating seasonal wetlands would involve constructing small berms and dikes. Because the terrain is flat, the berms rarely would need to be higher than 2 or 3 feet. Berms may be permanent or may be rebuilt each year at the end of the growing season. Berms usually would be constructed with native soils available at the site but may be built with imported materials. Because the berms would be small and would not need to withstand high water pressures, they could be built with relatively lightweight construction equipment or agricultural machines.

Constructing berms could increase the availability of sediment for discharge to waterbodies. However, because the berms would be built in agricultural fields already subject to extensive ground disturbance during cultivation, any increase in sediment erosion rates is expected to be small. The flatness of the terrain also discourages water-induced erosion.

Restoring seasonal wetlands would not involve a permanent change in land use. Agricultural lands would be managed for several months each year to increase habitat value for waterfowl and other birds. Agricultural land that otherwise would be wet but may not be inundated in winter and early spring would be flooded. The change in land management could produce a change in the emission rate of various substances and their concentrations in waterbodies. Because this action would affect about 6% of the agricultural land in the Delta, it could affect regional water quality.

Natural Organic Matter

The effects of converting agricultural lands to wetlands or shallow water aquatic habitat are discussed under "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands." It was assumed that conversion could lead to an increase or decrease in DOC emission of 65%. When restoring seasonal wetlands, agricultural land would continue to be cultivated but would be inundated for several months. Although no data are available to support the view, it seems probable that the creation of seasonal wetlands would increase the emission of TOC compared to existing conditions, because it combines cultivation, which disturbs and exposes peat soils to the atmosphere, with periodic inundation of standing water. For this analysis, it was assumed that TOC emission could be increased by up to 65%.

As noted earlier, the annual average DOC emission in agricultural drainage is about 17,000 tons, or 64 pounds per acre per year. If 24,000 acres of agricultural land were converted to wetland, the current annual DOC emission rate of 770 tons would increase to 1,270 tons. After restoring seasonal wetlands, the total annual DOC mass emission from Delta islands would be 17,500 tons, a 3% increase from existing conditions.

Pesticides

Pesticide emissions are a result of agricultural use of pesticides. The winter and spring use of agricultural land as seasonal wetlands would not alter agricultural activities on the land the remainder of the year. Pesticide emissions would not change.

Salts

As noted earlier, neither irrigated agricultural lands nor wetlands are net emitters of salts.

However, the concentration of salts in various waterbodies may change as a result of altered evaporation rates. The deliberate inundation of land for several months in winter would produce a small increase in the annual evaporation rate.

Nutrients

Nitrate emissions would not change, as discussed under "Restore Tidally Influenced Freshwater Marsh."

Restore Riparian Habitat

Corridors of riparian vegetation would be restored in the Delta along the San Joaquin River and its tributaries, and along the shores of islands. Between 7,000 and 8,000 acres of land would be affected.

Setback levees would be built behind existing levees, the existing levees would be demolished, and the materials would be used to create streamside benches on which riparian vegetation would be planted. Impacts would be similar to those discussed under "Restore Tidal Perennial Aquatic Habitat and Tidal Wetlands," but on a smaller scale.

Restoring corridors of riparian vegetation would increase shading of stream waters. Temperature would be the only water quality parameter directly affected. Water temperature in small streams could be reduced by several degrees where a dense canopy shades much of the water surface. Water temperature in broader streams and where the riparian corridor is fragmented would be reduced by lesser amounts.

However, any decrease in water temperatures due to increased shading in Delta channels and large rivers may be offset by solar heating of a larger water surface area flowing more slowly.

Water Quality Program, Including Coordinated Watershed Management

The Water Quality Program consists of actions designed to improve water quality in the Bay-Delta system and support all beneficial uses, including drinking water supply, recreation, agricultural and industrial water supply, and protection and enhancement of aquatic life. The program includes actions to reduce water quality degradation from agricultural drainage, urban and industrial runoff, mine drainage, and municipal and industrial (M&I) wastewater discharges. Most actions would reduce the discharge of elements of concern to waterways; others would change the timing of wastewater releases and relocate water supply intakes. The actions are organized by geographic region (Table 3).

Actions to curb contaminant emissions in mine drainage, urban and industrial stormwater runoff, and municipal and industrial wastewater treatment plant discharges are included for all regions except the SWP and CVP Service Areas Outside the Central Valley. Actions to reduce contaminant emissions from agricultural surface runoff or subsurface drainage are included for the Sacramento River and San Joaquin River basins and for the Delta. Actions to curb emissions of pathogenic microbes in wastes

Actions	Sacramento River Basin	San Joaquin River Basin	Delta	Bay	SWP and CVP Service Areas
Reduce heavy metal emissions in mine drainage	✓	✓	✓	✓	
Reduce emissions of contaminants in urban and industrial runoff	✓	✓	✓	✓	
Reduce emissions of contaminants in wastewater treatment plant discharges	✓	✓	✓	✓	
Reduce emissions of contaminants in agricultural surface runoff	✓	✓	✓		
Reduce emissions of contaminants in agricultural subsurface drainage		✓			
Relocate diversions to improve wastewater supply		✓	✓	✓	✓
Reduce discharge of pathogens from vessels	✓		✓		
Improve drinking water quality by treating raw water				✓	✓

Table 3. Water Quality Program Actions

from boats are included for the Sacramento River and Delta regions, the regions where boat wastes have the greatest potential to affect drinking water quality. An action involving the relocation of water supply intakes is included in the Delta Region because construction will have direct effects there, and in the San Joaquin River and Bay regions and the SWP and CVP Service Areas Outside the Central Valley because these areas will benefit from better water quality. An action involving improved treatment of municipal water supplies obtained from the Delta is included in the Bay Region and the SWP and CVP Service Areas Outside the Central Valley because the treatment plants to be modified and the consumers of better water would be located in those regions.

The Water Quality Program relies on improved enforcement of existing regulations and incentives for action that exceeds current regulations. The actions currently do not involve new regulations. However, consistent with CALFED's adaptive management philosophy, new regulations may be proposed later if current actions prove ineffective.

Reduce Heavy Metal Emissions in Mine Drainage

Drainage from inactive and abandoned mines is a source of cadmium, zinc, and mercury in streams tributary to the Delta. Abandoned mines are located on the Mokelumne (Penn and Newton mines) and Cosumnes rivers, and on creeks tributary to the Yolo Bypass. Heavy metals emissions would be reduced by sealing mines, removing and capping tailing piles, diverting streams around metal sources, and removing contaminated sediments from streambeds. Metal emissions would be reduced by 25 to 30%.

Metals concentrations in water and sediment could be expected to decline in the Delta. However, because the behavior of dissolved and particulate metals in natural aquatic systems is complex, it is difficult to predict the specific consequences. Although high loads of metals enter the Sacramento River Region from inactive mines, only a fraction of the total load appears to enter the Delta. This may be because the metals form complexes with inorganic or organic substances, and accumulate or decay in the system upstream of or within the Delta. Alternatively, it may simply be an indication that measurement methods and the estimates based on them are flawed. In general, it seems probable that this action would result in at least a minor reduction in metal concentrations in the Delta.

Data on metal loads from all sources contributing to the Delta are incomplete; the available estimates are shown in Table 4. A reduction of 25 to 30% in copper emissions from inactive

Source	Cadmium	Copper	Zinc
Mine drainage	NK	4	NK
Municipal and industrial wastewater	0.15	2	2
Urban runoff	0.14	6	NK
Total	**0.29**	**12**	**2**

NOTE:

NK = Not known.

SOURCE:
CALFED Water Quality Action Team 1997.

Table 4. Selected Metal Loads in Delta (thousands of pounds/yr)

and abandoned mines is projected to reduce basinwide emissions by about 8%. However, data are insufficient to make estimates of basinwide emission reductions of cadmium and zinc.

Reduce Emissions of Contaminants in Urban and Industrial Runoff

This action would vigorously enforce current stormwater regulations that apply to cities with populations over 100,000 and certain industries. In the Delta, the only urban area that has prepared a stormwater management plan and received a stormwater discharge permit is San Joaquin County (including the City of Stockton). The characteristics of typical urban stormwater from Stockton are shown in Table 5. It was assumed that future regulations would extend the stormwater management program to smaller cities, perhaps those with populations over 10,000. Economic penalties for noncompliance would be imposed, and incentives would be given for controls that exceed the minimum requirements.

Uncertainties exist regarding the effectiveness of current urban and industrial surface runoff controls and incentive-driven programs intended to enhance their effectiveness. For this assessment, it was assumed that aggressive enforcement of existing regulations and provision of incentives would reduce pollutant mass emissions in urban and industrial runoff from built-up areas by 5%, and from undeveloped areas by 20%, compared to the No Action Alternative. An average reduction of 10% was assumed.

Total metal loads imposed on the Delta directly are relatively small compared to those imposed in the Sacramento River and San Joaquin River regions. Urban and industrial runoff loads probably represent a considerable proportion of total direct metal loads entering the Delta. Implementing this action in the Delta Region would decrease current metal loads from urban

		Event Mean Concentration		
Constituent	Unit	Residential	Commercial	Industrial
Ammonia (as N)	mg/L	0.53	0.62	0.43
Biological Oxygen Demand	mg/L	13	11	13
Nitrate (as N)	mg/L	0.42	0.39	0.63
Oil and Grease	mg/L	0.9	1.1	1.5
Total Phosphorus	mg/L	0.37	0.33	0.43
Total Dissolved Solids	mg/L	65	50	105
Total Suspended Solids	mg/L	53	58	222
Total Cadmium	μg/L	0.34	0.85	0.62
Total Copper	μg/L	11.3	18.6	15.7
Total Chromium	μg/L	4.5	7.2	12.1
Total Lead	μg/L	15.0	23.6	13.5
Total Zinc	μg/L	119	194	139

SOURCE:

Kinnetic Laboratories 1994.

Table 5. Typical Characteristics of Urban Runoff from Stockton

and industrial runoff by about 10%. If metals in urban runoff represent one-third of the total basinwide load, the overall decrease would be 3%. However, compared to the No Action Alternative, this action only would reduce the rate of increase of pollutant emissions between 1997 and 2020. Pollutant emissions would increase from existing levels by about 40%, rather than 60%. Thus, implementation of the Water Quality Program would improve water quality compared to the No Action Alternative. However, conditions would still deteriorate relative to the present.

Compared to the No Action Alternative, the reduction would have a minor beneficial effect on water quality, with the greatest benefit accruing to small streams in urban areas where flow consists primarily of urban runoff.

Reduce Emissions of Contaminants in Wastewater Treatment Plant Discharges

Untreated M&I wastewater contains many parameters of concern, including metals and trace elements, natural and synthetic organic chemicals, salts, nutrients, and suspended solids. The federal Clean Water Act requires all M&I wastewater to receive at least secondary treatment before it is discharged to waters of the United States. Secondary treatment of municipal wastewater removes about 85% of the biochemical oxygen demand and total suspended solids (TSS) in the wastewater, and smaller proportions of metals, trace elements, and nutrients. Higher levels of treatment are required if the application of secondary treatment does not result in compliance with instream water quality standards.

All M&I wastewater discharges are the subject of permits issued pursuant to the National Pollutant Discharge Elimination System (NPDES). The Clean Water Act established the NPDES, a nationwide permitting system administered in California by the SWRCB and the RWQCBs. Discharge permits typically contain numerical effluent limits.

This action would vigorously enforce existing regulations affecting wastewater discharge—in effect the effluent limits and the pretreatment requirements—and provide incentives to encourage reductions in pollutant discharge that exceed current regulations. For this assessment, it was assumed that the program would result in a 0 to 10% reduction in waste loads from M&I treatment plants compared to the No Action Alternative, with the high end of the range used in the analysis.

Any construction activities associated with reducing emissions of contaminants from wastewater treatment plant discharges would be concentrated at municipal wastewater treatment plants and at industrial facilities. The acreage of land disturbed by construction would be small.

Dischargers with an average daily dry-weather discharge greater than 1 million gallons per day (mgd) in the Delta include the cities of Stockton, Lodi, Tracy, and Davis. The total average daily dry-weather flow of municipal wastewater is approximately 50 mgd, with about 60% of it originating from Stockton. The characteristics of current Stockton effluent are shown in Table 6.

The 10% reduction from current waste loads attributable to this action would improve water quality conditions close to the points of discharge relative to current conditions, particularly where the discharge is made to relatively quiescent receiving waters. Both ammonia toxicity, which has been identified as a problem in some Delta waters, and oxygen depletion, which has been a problem on the San Joaquin River near the City of Stockton, also would be reduced somewhat.

The population of the Central Valley is projected to grow from 4.6 million in 1997 to 7.2 million in 2020, an increase of approximately 60%. Assuming that the per capita emission of pollutants in wastewater remains constant and wastewater treatment levels remain the same, the overall emission of pollutants in urban runoff under the No Action Alternative would increase by 60% by 2020. Thus background water quality would deteriorate in response to increased pollutant emissions with the effects most noticeable near wastewater outfalls. Implementation of this action would reduce the rate of increase of pollutant emissions between 1997 and 2020. Pollutant emissions would increase by only 50% rather than 60%. Thus, implementation of the Water Quality Program would improve water quality compared to the No Action Alternative. However, water quality would still deteriorate relative to existing conditions.

If such deterioration in water quality occurs as a result of population growth, the result would be unacceptable to regulatory agencies. In many cases, regulatory agencies may impose more stringent effluent limits to maintain compliance with in-stream standards. Municipalities and industries may be required to increase treatment levels to meet the standards.

Implementation of this action within the Delta Region alone would have little effect on regional water quality conditions.

A potential indirect effect of vigorous enforcement of effluent limits and pretreatment requirements is industry relocation. If wastewater management costs for industries increased, they might choose to relocate to areas where wastewater treatment costs are lower. The environmental impacts of wastewater disposal then would be transferred from one place to another. Indirect impacts of this action are expected to be minor because the action itself is minor, in that it does not call for more stringent standards but only enforcement of existing standards.

Constituent	Unit	Monthly Average Concentration (January)	Monthly Average Concentration (May)
Biological oxygen demand	mg/L	4.3	5.4
Total suspended solids	mg/L	11	20
Conductivity	μmhos/cm	1146	1304
Ammonia	mg/L	18.3	< 0.2
Total coliform	MPN/100 ml	< 2.0	< 2.0
Oil and grease	mg/L	< 5.0	< 5.0
Total hardness	mg/L	147	173
Total dissolved solids	mg/L	623	769
Total cadmium	μg/L	NA	NA
Total copper	μg/L	NA	NA
Total lead	μg/L	NA	NA
Total mercury	μg/L	NA	NA
Total selenium	μg/L	NA	NA
Total zinc	μg/L	NA	NA

NOTE:

μmho/cm = micromhos per centimeter = μS/cm = microsiemens per centimeter
NA = Not analyzed
MPN = most probable number

SOURCE:
City of Stockton, Main Sewage Treatment Plant, Municipal Utilities Department 1997.

Table 6. Stockton Main Sewage Treatment Plant 1997 Effluent Quality

Reduce Emissions of Contaminants in Agricultural Surface Runoff

Agricultural drainage from cropland in the Delta is a mixture of surface runoff and subsurface drainage. Excess water drains from fields to perimeter ditches, either across the surface or through the surface soil layers. The general characteristics of Delta drainage water are shown in Table 2. Superficial soils in the Delta are not derived from marine sediments; consequently, drainage water does not contain elevated concentrations of selenium, boron, or other trace toxic substances. Drainage water does contain high concentrations of DOC.

Surface runoff from agricultural areas varies in quality, depending on the nature of the agricultural activity. Runoff from cropland is a large-volume dilute waste stream typically containing higher concentrations of salts, organic matter nutrients, suspended solids, and pesticides than runoff from lands not subject to agricultural use. Runoff may be produced by precipitation or by applied irrigation water. Runoff from rangeland typically contains higher concentrations of suspended solids than unused lands. Runoff from areas where domestic animals are confined or where large animals congregate contains elevated levels of salts, organic matter, nutrients, suspended solids, and pathogenic microbes.

Depending on their size, confined animal feeding operations may be regulated in the same way as M&I discharges, but discharges of agricultural runoff generally are unregulated. The Clean Water Act addresses non-point source pollution, including agricultural runoff, but does not call for a permitting program for agricultural runoff comparable with the urban runoff program. The act does provide for establishing a framework of voluntary controls of non-point sources of pollution.

Pesticide discharges in agricultural runoff are regulated by the State of California. The Central Valley Basin Water Quality Control Plan (Central Valley Regional Water Quality Control Board [CVRWQCB] 1994) prohibits the discharge of irrigation return flow containing certain pesticides (including carbofuran, one of the parameters of concern), unless management practices approved by the RWQCB are adhered to. Tailwater recovery is a promising best management practice (BMP) for control of runoff from cropland. (Refer to the "Mitigation Strategies" section.)

A pesticide management program similar to the successful cooperative program of rice growers and the CVRWQCB in the Sacramento Valley, could be effective in reducing pesticide discharges in the Delta. (Refer to "Mitigation Strategies.") Also, because drainage water on Delta islands flows to sumps from where it is pumped to Delta channels, opportunities may exist to modify the sumps to enhance removing TSS before discharge to the channels. It was assumed that application of voluntary control measures on agricultural runoff would produce a 20% reduction in pesticide discharges and a 10% reduction in the discharge of other contaminants.

Most measures used to control emission of contaminants in agricultural runoff do not involve construction or ground disturbance in excess of that already associated with agricultural operations and do not result in additional impacts. (Refer to "Mitigation Strategies.")

The effects of reductions in contaminant discharges in agricultural runoff are difficult to assess. If the volume of agricultural wastewater discharged to a stream remains the same while contaminant concentrations decrease, water quality could be improved. On the other hand, if the measures taken to reduce pollutant emissions also reduce the volume of agricultural wastewater discharge, as they do with tailwater recovery, the concentration of contaminants in receiving waters may increase or decrease, depending on the ratio of the discharged volume to the receiving water volume, and the relative volume of the receiving water.

Assuming no substantial change in the volume of agricultural wastewater, the reduction in contaminant discharge would improve water quality somewhat in Delta channels. Because irrigated agricultural land is the predominant land use in the Delta, regional water quality benefits also would be expected.

Relocate Diversions To Improve Water Supply Quality

This action would relocate existing water supply diversions to provide access to better quality water. The action refers to changes in diversion locations that are not included elsewhere in the CALFED alternatives. Several alternatives that are analyzed in detail involve major changes in diversion locations. For example, by providing a cross-Delta isolated conveyance facility, Alternative 3 in effect relocates the CVP and SWP intakes to the Sacramento River. Two diversion location changes are considered here: relocation of the intake for the North Bay Aqueduct from Barker Slough to the Sacramento River, and
relocation of the Contra Costa Canal Intake to Clifton Court Forebay in the event that better water quality is delivered there. (The No Action Alternative already includes relocation of the Contra Costa Canal Intake to Old River.)

Local impacts on water quality would result from canal or pipeline construction. Impacts would occur along the conveyance facility alignments. Most impacts would be associated with ground disturbance and would result from increased turbidities produced by accelerated erosion rates. Most construction activities would occur in dry conditions away from waterways. Exceptions would occur where the canal must cross a stream or Delta channel. Adverse impacts on water quality would be concentrated at these locations.

Relocating diversions would result in improvements in TDS, bromide, and TOC concentrations in water diverted for municipal supply, compared to present conditions. These improvements would be significant, even though Delta water quality is expected to deteriorate overall. They would occur under a variety of hydrologic conditions but would be most pronounced during dry periods. The improvements would benefit municipal water consumers in the Bay Area, the San Joaquin Valley and southern California. The changes in diversion locations could adversely affect water quality in Barker and Rock sloughs, because water circulation and mixing would be reduced in the absence of these diversions, thus allowing local contaminants to accumulate and increase in concentration.

Reduce Discharge of Pathogens from Recreational Craft by Enforcement of Existing Regulations and Provision of Incentives

The discharge of vessel wastes is already regulated by federal and state governments but enforcement is problematic. Pleasure craft that carry passengers for a fee are subject to regulation by the U.S. Coast Guard and must be equipped with marine sanitation devices. Marine sanitation devices include flow-through treatment systems and holding tanks. Private pleasure craft must be equipped with a holding tank; flow-through devices are not permitted.

Although these regulations have been in place for some time, sanitary surveys of rivers used as water supply sources continue to identify vessel wastes as a source of microbial contaminants. This is because even relatively small volumes of untreated human waste contain very high numbers of microbes. One liter of untreated sewage from a boat might be expected to contain 1 billion coliform bacteria organisms. By comparison, one liter of treated effluent from a municipal wastewater treatment plant might be expected to contain only 100 coliform organisms. Consequently, 1 liter of untreated waste discharged from a boat may have the same microbial pollution potential as 10 million liters (2.6 million gallons) of municipal effluent. Thus, a single small pleasure boat discharging untreated waste could have an adverse affect on microbial water quality equivalent to that of a city with a population of 25,000.

The microbial quality of surface waters used for drinking water supplies is important even though water is disinfected before being supplied to consumers. Conventional water treatment processes, including disinfection, remove most but not all microbes from the treated water. Some microbes, including the parasitic protozoa *Giardia* and *Cryptosporidium*, and their cysts, are resistant to disinfection and may pass through a treatment system to infect consumers. If a supplier draws from a relatively microbe-free water source, the chance of significant numbers of pathogenic organisms surviving the treatment process is very low. However, if the microbial quality of the source water is poor, the risk increases.

The microbial quality of waters used for body-contact recreation is also important. Discharges of untreated wastes from boats are likely to occur in the immediate vicinity of water-contact recreation activities and have the potential to cause violations of recreational water quality standards.

Existing regulations and legal authority to address the problem of boat wastes are adequate, but enforcement is problematic. Small private pleasure craft are not usually inspected to determine whether they are equipped with holding tanks. Even if they are properly equipped, some boat owners may choose to surreptitiously discharge them to surface waters rather than going to the trouble and expense of using pump-out stations. Compliance with regulations could be improved by more effective inspection of boats, perhaps linked to their licensing, and the provision of free pump-out service at conveniently located stations. The latter might be funded by boat registration fees. However, it is probably unrealistic to assume that full compliance with vessel waste regulations will ever be achieved.

The Delta Region is heavily used by recreational craft and by water-contact recreationists. There is considerable potential for microbial water pollution from boats. Water quality standards for recreation are probably violated at times, and the quality of water as a source of raw water supply degraded. Millions of people are supplied with water withdrawn from the Delta at the intakes to the North Bay Aqueduct, Contra Costa Canal, South Bay Aqueduct, California Aqueduct, and the Delta Mendota Canal.

The only short-term adverse impacts of this action would be those associated with the construction of new waste pump-out stations at waterfront locations. Minor and local increases in sediment discharge could occur at construction sites but these impacts would be reduced by the application of conventional construction impact mitigation measures.

Better compliance with vessel waste regulations could improve in-stream microbial water quality particularly during summer when recreational use of some water bodies is heavy and other source of microbes (such as urban and agricultural runoff) are not present. The risk to the health of recreational water users and consumers of drinking water obtained from surface waters also could be reduced, at least in theory. However, any health improvements are not likely to be noticeable because outbreaks of serious water-borne disease among recreationists and water consumers in California are very rare.

This action would have no long-term significant adverse impacts on water quality. Construction activities could have some short-term adverse effects on water quality, but they would be reduced to less-than-significant levels by use of conventional construction mitigation measures.

Levee System Integrity Program

Rehabilitate Existing Levees to PL 84-99 Standards

Under this action, the waterside of levees would be armored with riprap to ensure stability. Some levees also would incorporate waterside or landside berms that would add stability and provide wildlife habitats and opportunities. The action would be conducted on 1,100 total miles of levees, which would result in about 10,000 to 15,000 acres of levees to PL 84-99 standards (100-year protection—refer to the Supplement to the Draft Affected Environment Technical Report for Flood Control for a discussion of PL 84-99 standards.). It was assumed that the existing levees to be rehabilitated cover approximately 7,500 to 11,250 acres; consequently, this action would increase the total area of levees by about 2,500 to 3,750 acres. The area would involve primarily agricultural land conversion and represents about 1% of the total agricultural land in the Delta (538,000 acres).

Constructing berms, installing riprap, and widening levees on the waterside of existing levees would resuspend some borrow material and possibly some levee sediments, creating small turbidity plumes in and downstream of the berm construction areas. Existing suspended sediment concentrations in the Delta range from 20 mg/L during low-flow conditions to more than 1,000 mg/L during high-flow periods (Jones & Stokes Associates 1995). The effects of a short-term localized increase in turbidity and suspended solids were not considered potentially significant in the context of the large natural variability in the system.

Elements that tend to be associated with the sediments also may be resuspended and redissolved during construction activities. Such elements include metals, pesticides, nutrients, and natural organic matter (a source of DOC). Metals associated with sediments may be resuspended, and some portion of the metals may be redissolved; however, data on the levels of concentrations of metals of concern in levee sediments indicate that concentrations are generally below sediment guidelines developed by the San Francisco RWQCB (SFRWQCB) for wetland creation and upland reuse (SFRWQCB 1992). Data on pesticides of concern in sediments from stations in the Delta indicate levels that are generally below detection limits (Fox et al. 1996).

Natural Organic Matter

Program actions and activities may include creating berms, setting back levees, and widening levees. These activities would lead to converting adjacent lands, most likely in agricultural uses, to levees, riparian habitat, or wetland habitat. If agricultural lands underlain by peat soils were converted to levees and riparian habitat that did not contain peat soils (that is, if the peat content were removed), DOC emissions to Delta channels could decrease, resulting in positive impacts. When agricultural lands are converted to wetland habitat, the effects of changes in the DOC flux on Delta channels are still unknown based on initial pilot tests conducted as part of the Delta Wetlands Project (Jones & Stokes Associates 1995).

Salts

When water is siphoned from Delta channels and applied to agricultural land, some water is released to the atmosphere through evapotranspiration; some percolates into the ground, flushing salts from the surface sediments; and some drains into perimeter ditches. Percolated water, tailwater, and channel seepage are collected in these drainage ditches and pumped back into Delta channels. The volume of the drainage water is estimated to be 25 to 50% that of the applied water, and the average salt content of drainage water is two to four times greater than that of applied water. Although the salt loads in diverted and return flows are comparable, irrigated agriculture, by extraction of freshwater from channels, causes salt concentrations in Delta channels to increase.

The effect of conversion of agricultural lands to levees supporting riparian habitat depends on how the amount of evapotranspiration resulting from program actions compares to the No Action Alternative conditions. Evaporation from open water (which would reflect shallow-water habitat) is estimated to be about 55 inches per year, whereas evapotranspiration from cropland is approximately 30 to 35 inches per year. It was assumed that this action primarily would result in riparian vegetation, with net water demands less than those of current agricultural crops. Given this assumption, implementing the program is likely to result in decreased salinity loads entering Delta channels.

Pesticides

Concentrations of 30 pesticides from six agricultural drains in the Delta measured between 1983 and 1987 were all below detection limits, which ranged from about 0.01 to 10 grams per liter (g/l), depending on the parameter of concern. These data suggest that agricultural drains in the Delta are not a significant source of pesticides and, therefore, conversion of agricultural lands in the Delta would have little, if any, effect on pesticide loading in the Delta.

Nutrients

The nutrient of greatest concern in the Delta is nitrogen because it is considered to be the primary limiting nutrient in the Delta. The predominant form of nitrogen is nitrate-nitrogen because of relatively rapid biotransformation of other nitrogen forms (ammonia and nitrite) that commonly occur in oxygenated aquatic systems. Concentrations of nitrate in agricultural return flows tend to be about 10 to 20 mg/L. The primary sources of nitrogen from agricultural areas are fertilizers and nitrogen-fixing vegetation that obtains nitrogen from the atmosphere. In the Delta, the concentration of nitrate-nitrogen ranges from about 0.01 to 5 mg/L (Interagency Ecological Program 1994), which reflects various sources, including agriculture, from the Sacramento River and San Joaquin River regions, discharges from wastewater treatment plants, urban runoff discharges, and other sources. Given that the concentrations of nitrate in return flows are much higher than in Delta channels, converting agricultural lands to aquatic or riparian habitat probably would result in localized reductions in the concentration of nitrate-nitrogen emissions.

Metals

Activities conducted as part of this program may require importing soils for engineering purposes. Depending on the source, these soils could contain a range of concentrations of metals that could leach into Delta waters.

Create New Setback Levees

Setback levees would be constructed, leaving the existing waterside levees in place. The waterside levees would be breached to create aquatic and riparian habitat between the levees. The setback levees would require 30,000 to 45,000 acres of land, assumed to be primarily agricultural. The total area of agricultural land in the Delta is 538,000 acres.

This action is similar to the Ecosystem Restoration Program action in the Sacramento and San Joaquin River regions that would restore tidal perennial aquatic habitat and tidal emergent wetlands on 33,000 to 45,000 acres. Impacts would be similar to those described earlier for the Ecosystem Restoration Program in the Delta Region.

Implement Shallow Flooding for Subsidence Control

In areas with deep peat soils, oxidation causes subsidence, which in turn may affect the stability of adjacent levees. This action would increase the stability of these levees by flooding areas adjacent to levees where deep peat soils are present and by increasing the mass and decreasing the landside slopes of levees. The action assumes that the total area targeted for subsidence control is 30,000 to 60,000 acres and that landside berms, where constructed, would extend 30 to 50 feet inland from the levee. Primarily agricultural lands would be affected by
these actions.

Water Use Efficiency Program, Including Water Transfers

The water use efficiency program differs from other components of CALFED in that it does not consist of specific actions. The program primarily is concerned with establishing and implementing policies that would encourage municipal water agencies and irrigators to increase the efficiency of water use. Many water users already are increasing the efficiency of their water use in response to growing water shortages, public policy, and sentiment that favors efficient water use and economics. The Water Use Efficiency Program would further encourage and facilitate efficient water use. Practices to be encouraged include reductions in losses from water systems, adoption of efficient water management practices by agriculture, implementation of urban BMPs for water conservation, increased wastewater reuse, and market-driven water transfers.

Although the precise actions that local agencies would take under the No Action Alternative and in response to the CALFED Water Use Efficiency Program cannot be defined, their outcome can be estimated. Current trends toward water use efficiency would be accelerated by the influence of the CALFED program, such that M&I demand could be reduced by an estimated 10 to 20% compared to current demand, and 1 to 2 MAF of municipal wastewater could be recycled. For this analysis, it was assumed that one-half the increase in water use efficiency would be attributable to the CALFED Water Use Efficiency Program. Agricultural water use also would become more efficient, but saved water would be used on irrigable lands or to reduce groundwater overdraft. It was assumed that little water saved by agriculture would be returned to the system to support other beneficial uses.

Some facility construction would be needed to increase water use efficiency. Wastewater reclamation plants would be built, leaking irrigation canals would be repaired, and inefficient irrigation systems would be replaced by more efficient systems. All these construction activities would temporarily increase local water turbidity levels, but would not affect regional water quality.

Implementation of the Water Use Efficiency Program would not produce an absolute reduction in water withdrawals from the Delta, but it may slow the rate of increase. The program would reduce the total amount of water needed to sustain the expected level of population and economic activity in 2020 by 5 to 10%, to perhaps 6.6 MAF. If this reduction in total statewide need for water translated into lower withdrawals in the Delta, water quality in the Delta in 2020 would be better with the Water Use Efficiency Program in place than under the No Action Alternative. However, it is not clear whether the program would result in reduced withdrawals from the Delta. Municipal water users may choose, or be compelled by circumstances, to continue drawing the maximum they can from the Delta, and reduce use of their other sources. Contrary to water use efficiency objectives, agricultural users may choose to use the saved water themselves by switching to more profitable irrigation-intensive crops, place more land under irrigation, or sell their saved water to other users. Overall, it is difficult to predict how municipal and agricultural water users would respond to the water savings produced by the Water Use Efficiency Program and what effect their actions might have on flow and water quality in Central Valley rivers and the Delta.

Increased water use efficiency may in some cases reduce the total emission of pollutants from agricultural lands. A water efficiency measure that may be used is tailwater recovery, described under "Mitigation Strategies." Complete recycling of drainage water usually is not practical because of salt buildup in the recycled water, but the use of tailwater recovery systems undoubtedly reduces the discharge of soil particles to streams. It also may reduce the discharge of organics, nutrients, and pesticides associated with the soil particles. The discharge of salt also would be reduced because less water would be applied to each field and within each region to produce given sets of crops.

Viewed from a regional scale, more efficient use of water by agriculture would reduce the total amount of water and salt applied to agricultural lands. Less salt would need to be removed from agricultural areas for discharge to drainage canals, rivers, or streams. This benefit would accrue only if farmers chose to allow saved water to be used for nonagricultural beneficial uses, rather than using it for additional irrigation.

Reduced water use by municipalities and industries would reduce the volume of their wastewater discharges, but the mass load of pollutants from these sources would not be altered substantially. Consequently, the concentration of pollutants in M&I waste streams would increase by 5 to 10%. Although this amount is of little consequence for most receiving waters, it could adversely affect water quality in circumstances where the waste streams represent all, or substantial proportions of, the flows in streams. Improvements in urban landscape irrigation efficiency could reduce overwatering and the consequent discharge of contaminated runoff to storm drains and streams during summer.

Storage and Conveyance

The three primary CALFED alternatives include different combinations of water storage, water conveyance, and associated facilities. Certain facilities are common to several alternatives or alternative configurations. General water quality effects of construction and operation of the storage and conveyance components of the alternatives are described in this section. Although this discussion is not repeated, these general impacts apply to all of alternatives discussed in this and later sections of the report.

Apart from short-term construction impacts, the water quality effects of miscellaneous appurtenant facilities such as fish screens and trash racks, would be minor. To the extent that they affect the hydraulics, their effects would be factored into the effects of the larger facilities. However, there are some exceptions. For example, the effects of flow barriers and weirs may be unique to an alternative or alternative variation. To the extent feasible and appropriate for the programmatic document, the variations in impact will be identified when more specific model run results are available.

Water stored in upstream reservoirs could improve water quality in the Delta if and when flows were released to streams that flow into the Delta, and the flows reached the Delta. Releases of water from groundwater storage into surface streams during periods of low streamflow could have similar beneficial effects in the Delta if the flows reached the Delta. Some water could also be stored on Delta islands. Perimeter levees would be bolstered to form in-Delta reservoirs. Freshwater releases may then be made to provide additional water for diversion, augment Delta outflows, or provide environmental benefits in the Delta. Small-scale facilities would be needed to divert water from the system to storage, and return it to Delta channels when needed.

The release of water down the Sacramento River during low-flow periods could improve water quality in the river and in the Delta. Pollutants discharged by cities, industries, and agriculture would be diluted, and instream pollutant concentrations would be reduced. Freshwater outflows to San Francisco Bay may be increased, reducing the quantities of saline water entering the Delta from the Bay. Improved Delta water quality would benefit water users in the SWP and CVP Service Areas Outside the Central Valley by reducing the concentrations of salt and THM precursors in the diverted water.

The transfer of water into storage during high-flow periods would reduce the magnitude and duration of the high flows downstream, and could slightly reduce flood peaks. Although in most downstream waterbodies this would not be expected to have much effect on water quality, it could have minor consequences for San Francisco Bay. Periodic high outflows from the Delta have a profound effect on salinity concentrations in the Bay and may improve water circulation, especially in the South Bay. Reductions in the magnitude or frequency of high flows could affect the quality of Bay waters during and subsequent to high-flow events.

DWR developed a CALFED Post-Processing Operations Model to address the effects of potential new storage facilities on agricultural, urban, and environmental water supplies in the Delta (DWR 1997). A particular emphasis of the modeling efforts was to evaluate the sensitivity of water supply estimates to a range of operational parameters (such as storage carryover requirements), a range of export pumping capacities, and for achieving maximum supplies over a normal hydrologic period (Normal Period Supply Operation goal) or achieving maximum supplies during the driest years (Dry Period Supply Operation goal). Environmental targets also were included in the modeling as a surrogate for providing adequate Delta outflow and for providing flow events for maintaining geomorphological processes. Table 7 shows how the predicted environmental Delta outflow is affected by adding upstream-of-Delta storage for normal versus dry period operational goals and for two sets of allocation factors. This table shows that, for example, adding 2 MAF of storage is predicted to increase environmental supplies under Normal

	Delta Environmental Outflow			
	Normal Year			
Volume of Storage	100% Allocation	50% Allocation	100% Allocation	50% Allocation
0	3,780	3,780	2,400	2,400
1,000	4,170	4,030	2,830	2,500
2,000	4,270	4,100	3,250	2,650
3,000	4,320	4,130	3,250	2,800
4,000	4,350	4,150	3,250	3,050
5,000	4,370	4,170	3,250	3,050

NOTES:

Assumed conditions are normal period operations, 5,000-cfs capacity conveyance to off-stream storage, existing Delta pumping plant capacity, and low Sacramento River flow event target.

Stored water can be used for water supply or environmental benefits; 100 and 50% allocations for environmental benefits are shown in the table.

SOURCE:
CALFED 1997b.

Table 7. Effects of Upstream of Delta Off-Stream Storage on Environmental Delta Outflow (in TAF/year)

Year Operation on average by 13% (from 3,780 thousand acre-feet [TAF]/yr to 4,270 TAF/yr) if 100% of the reservoir storage is allocated to environmental supplies. and by about 9% (from 3,780 TAF/yr to 4,100 TAF/yr) if 50% of the reservoir storage is allocated to environmental supplies and the remaining 50% is allocated to urban and agricultural supplies. The potential water quality benefits of these additional supplies are described below for each constituent.

In-Delta reservoirs could be filled during high-flow periods, and water could be released back into Delta channels or directly to diversion pumps during low-flow periods. Three alternative configurations contain from 0 to 200 TAF of in-Delta storage. Various potential in-Delta surface water storage project sites have been identified. One alternative would involve flooding one or more islands and using them as storage reservoirs. Webb Tract and Bacon Island were identified as the preferred sites in a

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related project proposal (the Delta Wetlands Project). A discarded CALFED alternative, referred to as the "chain of lakes," would have involved flooding of a series of islands and using them as storage and an isolated cross-Delta conveyance facility. The reservoirs would have been connected by a series of siphons under Delta channels, and water would have been conveyed directly to the south Delta export pumps. A similar concept may be retained for through-Delta conveyance in the north Delta only, to obtain concurrent environmental benefits.

The nature of construction activities for in-Delta reservoirs would be different from those associated with conventional reservoir construction. Most impacts would be associated with ground disturbance and would consist of increases in turbidity and associated constituents caused by increased erosion rates. Impacts would be similar to those of the Levee System Integrity Program in the Delta Region.

Siphons connecting storage and conveyance components in the Delta could be built by tunneling under or trenching through Delta channels. In the latter case, some construction activities in Delta waters would be unavoidable. To minimize impacts, temporary cofferdams would be built to allow construction activities to be conducted in relatively dry conditions, but construction of the cofferdams themselves would result in increases in water turbidity.

The use of a Delta island for storage of water obviously would convert the land use from agricultural purposes to open water. The impacts of this change would be similar to some elements of the Ecosystem Restoration Program. Under this plan, large acreages of agricultural cropland would be converted to wildlife habitat, much of which would be shallow open water. Converting agricultural land to open water would reduce the emission of soil particles, nutrients, and pesticides to Delta waters. The emission of salts would remain about the same as under No Action Alternative conditions, but salt concentrations in Delta channels would increase due to increased evaporation rates. DOC emissions may increase or decrease.

The release of water into the Delta during periods of low Delta inflow would improve water quality. Pollutants discharged by cities, industries, and agriculture would be diluted; and instream pollutant concentrations would be reduced. Saline water entering from San Francisco Bay would be repelled. Improved Delta water quality would benefit water users in the SWP and CVP Service Areas Outside the Central Valley by reducing the concentrations of salt and THM precursors in the diverted water. Any improvement with respect to THM precursors could be offset if DOC concentrations increase when islands were flooded. Whether island flooding would increase or decrease DOC levels is not known.

Additional, alternative-specific discussions of the effects of storage are included in the impact section for each alternative.

Delta Conveyance

Delta conveyance components would convey water from the northern end of the Delta toward its southern end. Several different alignments for an isolated conveyance facility have been identified. Other conveyance improvements include expansion of existing Delta channels, including the Mokelumne forks and Old River.

Impacts would result from tunnel or siphon and canal construction activities. Most impacts would be associated with ground disturbance and would consist of increases in turbidity resulting from increased erosion rates. The extent of ground disturbance would depend on the type of construction employed and the need for construction of new roads to access the tunnel and canal sites.

Construction of new canals would involve ground and channel disturbances along the entire length of the canal. Most construction activities would occur in dry conditions away from waterways. Exceptions would occur at locations where a canal must cross channels. In most cases, small streams and drainageways could be temporarily diverted around construction activities. Because the Delta region is flat, siphons would be needed to carry canals under large waterways or small drainageways under canals. Siphon construction would require the placement of cofferdams in flowing streams, which would temporarily increase water turbidity.

Expansion of existing canals or other waterways probably would involve some construction in flowing water. Ground-disturbing earthwork would be scheduled during the dry season to the maximum extent possible.

Alternative Variation 1A

Construction activities (primarily limited dredging and filling) associated with relocating water supply intakes may have short-term impacts on water quality through the resuspension of sediment (including natural organic matter), and desorption of chemicals associated with those sediments. Construction under wet conditions would result in turbidity plumes near construction activities. Desorption of elements associated with sediments could increase toxicity to some aquatic organisms. If the materials required for fill contained constituents of concern, water quality impacts may be associated with the drainage of leachate into the Delta. Construction-related spills of fuels, lubricants, or other liquid or solid materials also could affect water quality.

Specific impacts would depend on the locations of the intakes, the type and extent of any required construction activities, the chemistry of dredge-and-fill sediments, and the type and extent of mitigation measures.

Salts

Figures 1 through 3 show model predictions of Alternative 1A for TDS at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The same model runs were used to represent Alternative 1A as were used to represent the No Action Alternative. Therefore, no comparison can be made between Alternative 1A and the No Action Alternative on the basis of current hydrodynamic or water quality modeling results.

The figures show averaged model predictions for the two extreme water-year types: wet and critically dry water years (the specific years within each water-year type are based on the Four-River Decision 1485 Water-Year Classification Index). Also shown for reference are the mean monthly measured data for wet and critical years obtained from DWR's MWQI Program or the IEP.

As shown in the figures, simulated salinity exhibits the characteristic seasonal pattern, with lower concentrations generally occurring from February through June. During these months, Delta outflow is maintained (primarily by adjusting SWP pumping and releases from storage) to meet the 2.64 EC isohaline criterion (also known as X2) at Chipps Island and Port Chicago. Higher Delta outflows are projected to reduce TDS concentrations, even during critically dry years, to concentrations around 200 mg/L. During late fall and winter, TDS concentrations would be higher and the simulations generally peak around December at 500 to 600 mg/L during critically dry years, and 300 to 400 mg/L during wet years. This effect is due primarily to lower Delta outflows during this period, caused by a combination of lower Delta inflow and increased SWP pumping. Predicted TDS concentrations at the North Bay Aqueduct intake at Barker Slough are relatively low (less than 200 mg/L) (Figure 3). Model predictions at the Tracy Pumping Plant Intake are not shown because the results are similar to those at Clifton Court.

DWR's service contract with the state water contractors requires that maximum monthly mean concentrations of exported water not exceed 440 mg/L. The predicted average values exceed this value in December and January during critically dry years (Figure 2). For the 15 years of hydrologic record (180 months) that encompass a variety of water-year types, predicted TDS concentrations exceed 440 mg/L in 23 months, or about 13% of all months. These exceedances were predicted to occur from September through February.

Delta channel flows and exports (primarily SWP) were adjusted in the model to manage salinity intrusion to meet the regulatory X2 requirements and other water quality and flow requirements in the Bay-Delta WQCP (SWRCB 1995) to the extent possible.

Natural Organic Matter

DBP precursors were modeled by DWR using DWRDSM1. The results from this preliminary modeling effort are presented to identify general trends and the likely order-of-magnitude of effects.

Figures 5 through 7 show model predictions of DOC at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show model predictions for two extreme water-year types: wet (water year 1986) and critically dry (water year 1987). Also shown for reference are the mean monthly measured data for wet and critical years (selected based on data availability) obtained from DWR's MWQI program or the IEP.

The figures show that predicted DOC concentrations for this alternative (and measured DOC) exhibit a strong seasonal variation, with peak DOC levels occurring in January and February. Predicted maximum values of DOC are highest at the North Bay Aqueduct (15 to 17 mg/L), moderate at the Contra Costa Canal Intake (7 to 9 mg/L), and lowest at Clifton Court (5 to 6 mg/L). Predicted (and measured) DOC concentrations also tend to be higher during wet years compared to critically dry years. These trends generally are consistent with DOC measurements from agricultural return flows.

Bromide

Figures 8 through 10 show model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show model predictions for two extreme water-year types: wet (water year 1986) and critically dry (water year 1987).

At the Contra Costa Canal Intake (Figure 8) and Clifton Court Forebay (Figure 9), predicted bromide concentrations exhibit a seasonal pattern, with low concentrations (generally less than 0.2 mg/L) from February through June and peak values around 1 mg/L in November through January. Concentrations also are higher during critically dry years compared with wet years. This pattern is similar to that for TDS and is consistent with the major source of bromide being seawater. At the North Bay Aqueduct intake at Barker Slough, predicted and measured concentrations are generally less than 0.2 mg/L, indicating that the effects of salinity intrusion are limited at this location.

Table 8 ranks the modeled alternatives for TDS, DOC, and bromide at three export facilities based on the predicted change in the mean annual concentration. A code of plus 2 to minus 2 is used to rank the alternatives. For example, plus 2 signifies an significant improvement in water quality and specifically corresponds to a decrease in the predicted mean annual concentration greater than 20%. Correspondingly minus 2 signifies a significant deterioration in water quality corresponding to a predicted increase in the mean annual concentrations greater than 20%. Predicted changes within plus or minus 10% are given a ranking of 0, which signifies no measurable change given the uncertainty in modeling. Intermediate changes between 11 to 20% are given a ranking of plus or minus 1 to signify some change, but not considered a significant change.

Based on these criteria, Table 8 indicates that the "through Delta" alternatives generally result in a significant improvement in TDS and bromide water quality at Clifton Court and Contra Costa Canal Intake. Under the "isolated facility" Alternative 3E, water quality for all three constituents is significantly improved at Clifton Court. However, DOC is predicted to be significantly poorer at Contra Costa Canal Intake under this alternative variation.

Alternative Variation 1C

Alternative Variation 1C involves extensive construction of surface storage facilities, new and expanded conveyance facilities, intake screens, and fish barriers. The duration of construction would vary depending on the facility, but major facilities may take a decade or more to construct. Much of the work would include earthmoving under wet conditions and would affect water quality by resuspending

Region	Constituent	Location	Water-Year Type	Alternative Variation 1A	1C	2B	2E	3E
Delta								
	Salinity (TDS)	Contra Costa	critical	N/A	0	2	2	0
		Clifton Court	critical	N/A	1	2	2	2
		NBA	critical	N/A	0	0	0	0
	DOC	Contra Costa	wet	N/A	0	-1	0	-2
		Clifton Court	wet	N/A	0	0	0	2
		NBA	wet	N/A	0	0	0	0
	Bromide	Contra Costa	critical	N/A	0	2	2	2
		Clifton Court	critical	N/A	1	2	2	2
		NBA	critical	N/A	0	-1	0	-1

NOTES:

N/A = Not available.
NBA = North Bay Aqueduct.
See Tables 9, 10, and 11 for actual values.

Codes:
2 = Predicted decrease in mean annual concentration of 21% or higher.
1 = Predicted decrease in mean annual concentration of 11 to 20%.
0 = Predicted mean annual concentration with + or - 10%.
-1 = Predicted increase in mean annual concentration of 11 to 20%.
-2 = Predicted increase in mean annual concentration of 21% or higher.

Table 8. Water Quality Impacts Summary Table (Relative to No Action Alternative)

C-009440

Location	Current Conditions Wet Year	Current Conditions Critical Year	No Action Alternative Wet Year	No Action Alternative Critical Year	1A Wet Year	1A Critical Year	1C Wet Year	1C Critical Year	2B Wet Year	2B Critical Year	2D Wet Year	2D Critical Year	2E Wet Year	2E Critical Year	3E Wet Year	3E Critical Year
Contra Costa Canal Intake	176	452	217	342	217	342	213	335	146	178	137	162	145	177	222	350
Clifton Court Forebay	179	307	194	295	194	295	207	328	164	226	164	230	164	224	117	164
North Bay Aqueduct	179	194	N/A	139	N/A	139	N/A	139	N/A	144	N/A	143	N/A	145	N/A	143
Jersey Point	N/A	N/A	383	788	383	788	379	779	194	401	189	381	185	331	230	462
Emmaton	N/A	N/A	294	795	294	795	291	789	349	892	332	840	298	815	368	879
Prisoners Point	N/A	N/A	142	159	142	159	144	161	120	113	120	115	118	111	189	239

Model Predictions columns: No Action Alternative and Alternative Variation (1A, 1C, 2B, 2D, 2E, 3E).

NOTES:

N/A = Not available.
Modeling based on DWRSIM 472B assumptions.

SOURCES:
Model Predictions: DWR 1997c, DWR 1997e. Historical Data: Interagency Ecological Program for the Sacramento - San Joaquin Estuary, DWR Municipal Water Quality Investigations (MWQI) Program.

Table 9. Model Predictions and Current Conditions for Mean Annual TDS (mg/L)

C-009440

Location	Current Conditions		Model Predictions: No Action Alternative		Alternative Variation: 1A		1C		2B		2D		2E		3E	
	Wet	Critical	Wet	Critical	Wet	Critical	Wet	Critical	Wet	Critical	Wet	Critical	Wet	Critical	Wet	Critical
Contra Costa Canal Intake	0.112	0.301	0.369	0.572	0.369	0.572	0.342	0.539	0.107	0.139	0.111	0.149	0.109	0.133	0.262	0.352
Clifton Court Forebay	0.104	0.311	0.297	0.476	0.297	0.476	0.284	0.389	0.248	0.346	0.243	0.328	0.243	0.330	0.055	0.066
North Bay Aqueduct	N/A	0.048	0.101	0.072	0.101	0.072	0.100	0.072	0.111	0.080	0.110	0.080	0.104	0.077	0.109	0.081

NOTES:

N/A = Not available.
Modeling based on DWRSIM 472B assumptions.

SOURCES:
Model Predictions: DWR 1997b. Historical Data: DWR Municipal Water Quality Investigations (MWQI) Program.

Table 10. Model Predictions and Current Conditions for Mean Annual Bromide (mg/L)

C-009441

Location	Current Conditions		No Action Alternative		Model Predictions — Alternative Variation 1A		1C		2B		2D		2E		3E	
	Wet Year	Critical Year	Wet Year	Critical Year	Wet Year	Critical Year	Wet Year	Critical Year	Wet Year	Critical Year	Wet Year	Critical Year	Wet Year	Critical Year	Wet Year	Critical Year
Contra Costa Canal Intake	3.70	4.32	3.90	3.46	3.90	3.46	3.89	3.51	4.39	4.26	4.37	4.29	3.71	3.31	5.09	5.92
Clifton Court Forebay	3.33	4.17	3.99	3.97	3.99	3.97	4.23	4.39	4.32	4.54	4.24	4.47	4.08	4.16	2.32	2.36
North Bay Aqueduct	5.51	5.12	6.58	4.96	6.58	4.96	6.56	4.96	6.96	5.35	6.93	5.33	6.73	5.19	6.97	5.36

NOTE:

Modeling based on DWRSIM 472B assumptions.

SOURCES:
Model Predictions: DWR 1997b. Historical Data: DWR Municipal Water Quality Investigations (MWQI) Program.

Table 11. Model Predictions and Current Conditions for Mean Annual DOC (mg/L)

C-009442

sediment, and possibly desorbing chemicals from those sediments. Construction in the Delta would result in turbidity plumes in the vicinity, and somewhat downstream, of construction activities. If materials required for fill contained constituents of concern, water quality impacts may be associated with the leachate drainage into Delta channels. Construction also could cause spills of fuels, lubricants, or other liquid or solid construction-related contaminants.

Overall model predictions for Alternative 1C are very similar to those for those for the No Action Alternative; however, the modeling does not account for additional storage associated with Alternative 1C which should result in overall improved water quality as discussed above. On this basis, the water quality under this alternative should be comparable to or better than the water quality associated with No Action Alternative conditions.

Salts

Figures 1 through 3 show model predictions of TDS at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct at Barker Slough. Except for Barker Slough, which shows only critical year results, the figures show model predictions for the two extreme water-year types: wet and critically dry water years. Also shown for reference are the mean monthly measured historical data for wet and critical years obtained from DWR's MWQI program or the IEP.

At the Contra Costa Canal Intake and Clifton Court, a seasonal pattern of salinity is exhibited, with lower concentrations occurring from February through June. During these months, Delta outflow is maintained (primarily by adjusting SWP pumping and reservoir releases) to meet the 2.64 EC criteria (also known as X2) at Chipps Island and Port Chicago. Based on these modeling results, Delta outflows reduce TDS concentrations, even during critically dry years, to 200 to 300 mg/L during February through June. During late fall and winter, TDS concentrations are higher and peak around December at 500 to 600 mg/L during critically dry years, and 300 to 400 mg/L during wet years. This effect is due primarily to lower (and or negative) Delta outflows during this period, caused by a combination of lower Delta inflows and increased SWP and CVP pumping. Predicted concentrations of TDS at North Bay Aqueduct at Barker Slough are relatively low and indistinguishable from the No Action Alternative.

The predicted TDS concentrations under Alternative Variation 1C at Clifton Court Forebay are slightly higher than the concentrations predicted under the No Action Alternative during critically dry years. However, during wet years they are indistinguishable from the No Action Alternative. Predicted TDS concentrations at the Contra Costa Canal Intake are not significantly different from the No Action Alternative.

DWR's service contract with the state water contractors imposes a maximum monthly mean concentration of 440 mg/L. For the 15 years (180 months) of hydrologic record simulated, predicted TDS concentrations exceed 440 mg/L in 33 months, or about 18% of all months. These exceedances are predicted to occur from August through February.

Salinity intrusion was managed in the model (primarily by adjusting SWP exports) to meet the regulatory X2 requirements and other water quality and flow requirements as specified in the WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995). Figure 4 shows the DWR model predictions of the mean maximum monthly X2 locations in critically dry years for all the alternatives modeled. The values for Alternative Variation 1C from February through June (during which the X2 regulatory requirement applies) vary from 76.8 kilometers in March to 84.4 kilometers in April. The X2 requirements specify the number of days in each of the months from February through June that the X2 location should be maintained at Chipps Island and Port Chicago, depending on the flow index for the eight rivers that enter the Delta. These requirements therefore are implicit requirements for flow releases.

There is a strong seasonal pattern in X2, with lower values from February through June when the X2 requirements are specified. For Alternative Variation 1A and the No Action Alternative, maximum X2 locations varied from 76.8 kilometers (measured from the Golden Gate Bridge) for March to 92.7 kilometers in September. For a given month, variations among the alternatives are small (2 kilometers or less) relative to seasonal differences. From February through June, values tend to be somewhat lower for Alternatives 2 and 3 when compared to Alternative 1.

Natural Organic Matter

Figures 5 through 7 show model predictions of DOC at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show model predictions for two extreme water-year types: wet (water year 1986) and critically dry (water year 1987). Also shown for reference are monitoring data for wet and critical years (selected based on data availability) obtained from DWR's MWQI Program or the IEP.

At the Contra Costa Canal Intake, the predicted DOC concentrations for Alternative 1C for both year types are indistinguishable from the No Action Alternative. Both the wet and critical years show February to March peaks in DOC of about 5 and 8 mg/L respectively (Figure 5). The effect of water-year type is not pronounced except in February. Predicted concentrations of DOC at Clifton Court Forebay range between about 4 and 6 mg/L. The figures show that predicted DOC for Alternative Variation 1C (and measured DOC) exhibits a seasonal pattern, with peak DOCs occurring in January and February. Predicted DOCs are generally higher for Alternative 1C than for the No Action Alternative, especially outside the January to February period.

Maximum predicted values of DOC are highest at the North Bay Aqueduct (15 to 17 mg/L), moderate at the Contra Costa Canal Intake (7 to 9 mg/L), and lowest at Clifton Court (5 to 6 mg/L). Predicted and measured DOC concentrations are generally higher during wet years compared to critically dry years.

Bromide

Figures 8 through 10 show model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct for wet and critically dry water-year types. Also shown, for reference to existing conditions, are the mean monthly measured data for wet and critical years (selected based on data availability) obtained from DWR's MWQI program or the IEP.

Because the Bay is the primary source of bromides in the Delta, the seasonal and inter-annual variability in bromide concentrations can be largely explained by the extent of salinity intrusion. At the Contra Costa Canal Intake, predicted bromide concentrations exhibit a seasonal pattern, with low concentrations (generally less than 0.2 mg/L) from February through June when Delta outflow is largely managed for X2 control. During November through January, concentrations peak at around 1 to 1.4 mg/L, with the higher values corresponding to critically dry years (Figure 8). Concentrations are generally lower at Clifton Court (less than 0.5 mg/L), where the effects of salinity intrusion from the Bay (the major source of bromides) are less pronounced (Figure 9). During critical years, predicted and measured bromide concentrations at the North Bay Aqueduct are very low (generally less than 0.2 mg/L), indicating that the effects of salinity intrusion at this location are minimal (Figure 10).

When compared with No Action Alternative conditions, predicted bromide concentrations at Contra Costa Canal Intake are slightly lower than the No Action Alternative during July through January, and are comparable during February through June. At Clifton Court Forebay, both critical and wet year projections are much lower than the No Action Alternative from September through January, whereas predictions for the remainder of the year vary considerably.

Nutrients

Although no CALFED actions would cause a significant decrease in nutrient discharges into the Delta, Alternative Variation 1C would improve circulation in the sloughs and rivers in the south Delta and should result in fewer and less intense algal blooms, along with their attendant low dissolved oxygen conditions.

Effects of Storage

Model predictions do not account for the effects of storage, which under Alternative Variation 1C includes 3 MAF of upstream storage on the Sacramento River tributaries, 1 MAF of south-of-the-Delta off-aqueduct storage, and 500 TAF of groundwater storage in the Sacramento and San Joaquin valleys. Preliminary DWRSIM modeling was conducted to evaluate the effects of surface storage on environmental flows and water supply. Details regarding the approach, assumptions, and limitations of the modeling are presented in CALFED Bay-Delta Program System Operation Modeling Studies for Impact Team Analysis (DWR 1997d).

The effects of storage on water quality in the Delta depend on operational considerations but generally would tend to improve water quality by redistributing flows from wet to dry months, and from wet to dry years. These additional flows would be obtained from surface water and groundwater storage, which would be operated to capture excess or unregulated flows when water quality was generally good and when diversions to storage would have the least impact on water quality in the Delta. For Alternative Variation 1C, the modeling predicts an additional 540 TAF/year (for environmental or consumptive use) during critically dry periods, and on average 600 TAF/year over the 73-year simulated period. Such additional supplies could substantially improve overall water quality. Depending on the type of outlet structure associated with additional storage facilities, water temperature and dissolved oxygen could be reduced, and turbidity in river reaches downstream from the reservoirs could be increased.

Alternative Variation 2B

Alternative Variation 2B would involve extensive construction of surface storage facilities, new and expanded conveyance facilities, intake screens, and fish barriers. The duration of construction would vary depending on the facility, but major facilities could require a decade or more to construct. Much of this work would include earthmoving under wet conditions and would affect water quality through the resuspension of sediment and possible desorption of chemicals from those sediments. Construction in the Delta would result in turbidity plumes in the vicinity, and somewhat downstream, of construction activities. If materials required for fill contained parameters of concern, water quality impacts may be associated with the leachate drainage into Delta channels. Construction also could cause spills of fuels, lubricants, or other liquid or solid construction-related contaminants.

Salts

Figures 11 through 13 show model predictions of TDS at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North

Bay Aqueduct. The figures show model predictions for the two extreme water-year types: wet and critically dry water years. Also shown for reference, are the mean monthly measured data for wet and critical years obtained from DWR's MWQI program or the IEP.

The salinity at the three locations is predicted to be uniform over the year, with TDS concentrations generally in the range of 100 to 300 mg/L, depending on the water-year type. Model results at other Delta locations also are discussed below.

Substantial improvement in salinities are observed at Jersey Point compared to the No Action Alternative. Decreases in salinity of 10% or more are observed 75% of the time. Median decreases are about 40 to 50%. Essentially no increases in salinity are observed. Decreases in salinity of up to 70% are possible compared to the No Action Alternative.

Under Alternative Variation 2B, salinity at Emmaton appears to increase substantially. On average, about 65% of the monthly salinities increased by more than 10%. Most of the increases occur in July through December. Alternative configurations 2A, 2D, and 2E also show decreases in salinity in the late fall and winter.

Alternative Variation 2B increases salinity in Old River during April and May about 50% of the time, with increases ranging from 10 to 30%. However, during the remaining months, Alternative Variation 2B reduces salinity on Old River. The summer through winter months exhibit decreases in salinity of 10% or more 50 to 100% of the time.

Salinities are improved substantially at the Contra Costa Canal Intake for both year types in all months except March through June. Predictions of TDS concentrations at the Contra Costa Canal Intake are comparable to the No Action Alternative during early spring, and much lower (by as much as 200 to 400 mg/L) during October through January.

Alternative Variation 2B also appears to improve salinity at Clifton Court Forebay. Overall, as many decreases as increases in salinity tend to occur. However, the decreases are greater in magnitude than the increases. TDS concentrations at Clifton Court Forebay are comparable to the No Action Alternative during early spring, and much lower (by as much as 200 to 400 mg/L) during October through January. The small increases occur mostly in the late spring and summer.

Predicted TDS concentrations at the North Bay Aqueduct are very comparable to the No Action Alternative.

These results indicate that Alternative Variation 2B decreases salinity in the central and southern Delta Region. The channel improvements and habitat improvements that increase the flow of Sacramento River water into the central and south Delta substantially reduce salinity. Moderate improvements are observed at Clifton Court Forebay. With the increase in cross-Delta flows, and corresponding decrease in Sacramento River flows, salinity is increased on the Sacramento River at Emmaton.

Because channel improvements are included in Alternative configurations 2A and 2B, these variations may have a similar effect on salinity as Alternative configurations 2D and 2E.

Under Alternative Variation 2B, the maximum monthly mean concentration of 440 mg/L at Clifton Court was not exceeded over the 16-year simulated period.

Salinity intrusion was managed in the model (primarily by adjusting SWP exports) to meet the regulatory X2 requirements and other water quality and flow requirements as specified in the WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995). Figure 4 shows the DWR model predictions of the mean maximum monthly X2 location in critically dry years for all the alternatives modeled. The values for Alternative Variation 2B from February through June (during which the X2 regulatory requirement applies) vary from 76.4 kilometers in February to 84.6 kilometers in May.

Natural Organic Matter

Predicted concentrations of DOC under this alternative are generally comparable to concentrations under the No Action Alternative, but the predicted concentrations do not take into account the effects of storage associated with Alternative Variation 2B. Such storage would tend to reduce concentrations, especially during critical years, to values below the No Action Alternative. Figures 14 through 16 show model predictions of DOC concentrations at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The figures show model predictions for the two extreme water-year types: wet and critically dry. Also shown for reference are monitoring data for wet and critical years (selected based on data availability) obtained from DWR's MWQI program or the IEP.

At the Contra Costa Canal Intake, the predicted concentrations show a peak in DOC concentration of about 7 to 8 mg/L occurring in February and March (Figure 14). Predicted concentrations of DOC at Clifton Court Forebay are relatively constant under Alternative Variation 2B; values range between about 4 to 6 mg/L (Figure 15). The effect of water-year type at these two locations is not pronounced. In contrast, maximum values of DOC are substantially higher at the North Bay Aqueduct, with peak concentrations of about 14 mg/L during critically dry water years and about 8 mg/L during wet years. The seasonal trends at the North Bay Aqueduct and Contra Costa Canal Intake are generally consistent with DOC measurements from agricultural return flows, supporting the general understanding that agricultural return flows are a major source of DOC in the Delta. The relatively high concentrations at the North Bay Aqueduct suggest that agricultural return flows make up a larger proportion of the source water at this location.

Bromide

Figures 17 through 19 show model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct Intake at Barker Slough. The figures show model predictions for the two extreme water-year types and for reference, the mean monthly measured data for wet and critical years (selected based on data availability) obtained from DWR's MWQI program or the IEP.

At the Contra Costa Canal Intake, predicted bromide concentrations are relatively low (less than 0.3 mg/L) and do not show a seasonal pattern or effect of water-year type (Figure 17). Wet year concentrations are generally comparable to existing conditions. Predicted bromide concentrations at the Contra Costa Canal Intake are comparable to the No Action Alternative during February through June, and much lower (by as much as 1 mg/L) during October through January.

Bromide concentrations at Clifton Court show a seasonal pattern during wet years, with relatively low concentrations (less than 0.2 mg/L) from February through June. (This is the period when Delta outflow is largely governed by the X2 regulatory requirements.) During critical years, bromide concentrations are higher during this period. At Clifton Court Forebay, predicted bromide concentrations are lower than concentrations simulated for the No Action Alternative in November through January; otherwise concentrations are higher than those in the No Action Alternative. Again, this comparison of model results does not consider the effects of storage, which are expected to reduce concentrations below those predicted.

Predicted bromide concentrations at the North Bay Aqueduct are very low (generally less than 0.2 mg/L), indicating that the effects of salinity intrusion at this location are minimal (Figure 19). Predicted bromide concentrations are comparable to those of the No Action Alternative.

Nutrients

Refer to the discussion of nutrients for Alternative Variation 1C.

Effects of Storage

Alternative Variation 2B includes 3 MAF of upstream storage on the Sacramento River tributaries, 2 MAF of south-of-the-Delta off-aqueduct storage, 500 TAF of surface storage in the San Joaquin Valley, 500 TAF of groundwater storage in the San Joaquin Valley, and 250 TAF of groundwater storage in the Sacramento Valley. Preliminary DWRSIM modeling was conducted to evaluate the effects of surface storage on environmental flows and water supply.

According to preliminary modeling results, Alternative Variation 2B would yield on average an additional 540 TAF/year during critical years, and 600 TAF/year during the 73-year hydrologic sequence. These additional flows would be obtained from surface water and groundwater storage that would be operated to capture excess or unregulated flows when water quality is generally good and when diversions to storage would have the least impact on water quality in the Delta. Depending on the type of outlet structure associated with additional storage facilities, water temperatures may be reduced, dissolved oxygen may be lower, and turbidity in river reaches downstream of the reservoirs may increase.

Table 8 shows the scores based on a comparison of predicted water quality with the No Action Alternative (assumed to be represented by Alternative Variation 1A). Significant water quality improvements are projected to occur for salinity at the Contra Costa Canal Intake and Clifton Court, and for bromide at the Contra Costa Canal Intake.

Alternative Variation 2D

Refer to the discussion for Alternative Variation 2B concerning construction activities associated with storage and conveyance.

Salts

Figures 20 through 22 show model predictions of TDS at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. Salinities at Contra Costa Canal Intake and Clifton Court Forebay are predicted to be quite uniform seasonally, with TDS concentrations generally in the range of 100 to 300 mg/L, depending on water-year type. Model predictions for Alternative Variation 2D were compared to predictions for the No Action Alternative. TDS concentrations at the Contra Costa Canal Intake are lower than those associated with the No Action Alternative during July through January. TDS concentrations at Clifton Court Forebay are comparable to the No Action Alternative during February through June, and much lower (by as much as 200 mg/L) during October through January. Predicted TDS at the North Bay Aqueduct are very similar to concentrations associated with the No Action Alternative.

The maximum monthly mean concentration of 440 mg/L TDS at Clifton Court never was exceeded over the 16-year simulated period for Alternative Variation 2D.

Salinity intrusion was managed in the model (primarily by adjusting SWP exports) to meet the regulatory X2 requirements and other water quality and flow requirements as specified in the

WQCP for San Francisco Bay/Sacramento San Joaquin Delta Estuary (SWRCB 1995). Figure 4 shows the DWR model predictions of the mean maximum monthly X2 location in critically dry years for all the alternatives modeled. The values for Alternative Variation 2D from February through June (during which the X2 regulatory requirement applies) vary from 75.2 kilometers in February to 83.6 kilometers in May.

Natural Organic Matter

Figures 23 through 25 show model predictions of DOC at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. Predicted concentrations of DOC at all three locations are comparable to concentrations projected for the No Action Alternative. At the Contra Costa Canal Intake, the predicted concentrations show a peak in DOC occurring in February (Figure 23). For wet years, the peak concentration is about 7 mg/L, whereas for critical years the peak concentration is about 6 mg/L. Concentrations of DOC at Clifton Court Forebay are relatively constant under Alternative Variation 2D; values range between about 4 to 6 mg/L (Figure 24). The effect of water-year type at these two locations is not pronounced. In contrast, maximum values of DOC are substantially higher at the North Bay Aqueduct, with predicted peak concentrations of about 14 mg/L during critically dry water years and about 8 mg/L during wet years. The seasonal trends at the North Bay Aqueduct and Contra Costa Canal Intake are generally consistent with DOC measurements from agricultural return flows, supporting the general contention that agricultural return flows are a major source of DOC in the Delta. The relatively high concentrations at the North Bay Aqueduct suggest that agricultural return flows make up a larger proportion of the water at this location.

Bromide

Figures 26 through 28 show model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and at the North Bay Aqueduct Intake at Barker Slough. At the Contra Costa Canal Intake, predicted bromide concentrations are relatively low (less than 0.3 mg/L) and do not show a seasonal pattern or strong effect of water-year type (Figure 26). Wet-year concentrations are generally comparable to existing conditions, whereas critical-year concentrations are lower than measured, particularly during October through January. Bromide concentration at Clifton Court shows a seasonal pattern during wet years, with relatively low concentrations (less than 0.2 mg/L) during February through June, when Delta outflow is largely governed by the X2 regulatory requirements. During critical years, bromide concentrations are higher during this period. In general, predicted concentrations at this location tend to be higher than measured. Predicted bromide concentrations at the Contra Costa Canal Intake are comparable to the No Action Alternative during February through June, and much lower (by as much as 1 mg/L) during October through January. At Clifton Court Forebay, predicted bromide concentrations are lower than concentrations under the No Action Alternative in November through January; otherwise, concentrations are higher than those in the No Action Alternative. At the North Bay Aqueduct, bromide concentrations are similar to the No Action Alternative. Predicted (and measured) bromide concentrations at the North Bay Aqueduct are very low (generally less than 0.2 mg/L), indicating that the effects of salinity intrusion at this location are minimal (Figure 28).

Nutrients

Conversion of agricultural lands to wetlands would likely decrease nutrient discharges which, coupled with improved circulation in the sloughs and rivers in the south Delta, should mitigate or prevent algal blooms and attendant low dissolved oxygen conditions.

Effects of Storage

Model predictions do not take into account the effects of storage. Alternative Variation 2D includes 2 MAF of south-of-the-Delta off-aqueduct storage. Preliminary DWRSIM modeling was conducted to evaluate the effects of surface storage on environmental flows and water supply. Details regarding the approach, assumptions, and limitation of the modeling is presented in CALFED Bay-Delta Program System Operation Modeling Studies for Impact Team Analysis (DWR 1997d). Modeling predicts that storage associated with Alternative Variation 2D would yield 220 TAF/year of additional volume (for environmental or consumptive use) during critically dry years. For the 73-year hydrologic sequence, on average, 370 TAF/year are projected to be available. The effects of storage on water quality would depend on the size and location of the facilities, and operational considerations. Storage generally would improve water quality by redistributing flows from wet to dry months, and from wet to dry years. Given that this alternative includes only south-of-Delta storage, the potential for improving water quality in the Delta would be limited by pump and conveyance capacities linking the additional storage to the Delta.

Table 8 shows the scores for Alternative Variation 2D based on a comparison of predicted water quality with the No Action Alternative. Significant water quality improvements are projected to occur for salinity at the Contra Costa Canal Intake and Clifton Court, and for bromide at the Contra Costa Canal Intake.

Alternative Variation 2E

Construction impacts for Alternative Variation 2E would be similar to those described for Alternative Variation 2B.

Salts

Figures 29 through 31 show model predictions of TDS at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. Salinity at the Contra Costa Canal Intake and Clifton Court Forebay is predicted to be relatively uniform seasonally, with TDS concentrations generally in the range of 100 to 300 mg/L depending on water-year type. Model predictions for Alternative Variation 2E were compared to predictions for the No Action Alternative. TDS concentrations at the Contra Costa Canal Intake are comparable to the No Action Alternative during February through June, and substantially lower (by as much as 400 mg/L) during other months. TDS concentrations at Clifton Court Forebay are comparable to the No Action Alternative during February through June, and much lower (by as much as 200 mg/L) during October through January. Predicted TDS concentrations at the North Bay Aqueduct are almost identical to predicted concentrations associated with the No Action Alternative.

Under Alternative Variation 2E, zero exceedances of the maximum monthly mean concentration of 440 mg/L at Clifton Court occurred over the 16-year simulated period.

Salinity intrusion was managed in the model (primarily by adjusting SWP exports) to meet the regulatory X2 requirements and other water quality and flow requirements as specified in the WQCP (SWRCB 1995). Figure 4 shows the DWR model predictions of the mean maximum monthly X2 location in critically dry years for all alternatives modeled. The values for Alternative Variation 2E from February through

June (during which the X2 regulatory requirement applies) vary from 74.9 kilometers in February to 83.5 kilometers in May.

Natural Organic Matter

Figures 32 through 34 show model predictions of DOC at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. Predicted concentrations of DOC at all three locations are comparable to concentrations under the No Action Alternative. At the Contra Costa Canal Intake, the predicted concentrations show a peak in DOC concentrations occurring in February (Figure 32). For wet years, the peak concentration is about 7 mg/L, whereas for critically dry years the peak concentration is about 4 mg/L.

Clifton Court Forebay shows a seasonal trend, with a peak in February of around 6 mg/L; water-year type appears to have little effect (Figure 33). Peak values of DOC are substantially higher at the North Bay Aqueduct, with peak predicted concentrations of about 14 mg/L during wet water years and about 8 mg/L during critically dry years (Figure 34).

The seasonal trends, with a peak around February, are generally consistent with DOC measurements from agricultural return flows, supporting the general contention that agricultural return flows are a major source of DOC in the Delta. The relatively high concentrations at the North Bay Aqueduct suggest that agricultural return flows make up a larger proportion of the source water at this location.

Bromide

Figures 35 through 37 show model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and at the North Bay Aqueduct Intake at Barker Slough. Predicted bromide levels at Contra Costa Canal Intake are relatively low (less than 0.3 mg/L) and do not show a seasonal pattern or effect of water-year type (Figure 35). Predicted bromide concentrations are similar to the No Action Alternative during February through June, and much lower (by as much as 1 mg/L) during other months.

Predicted bromide concentrations at Clifton Court show a seasonal pattern, with relatively low concentrations (less than 0.4 mg/L) during February through June, when Delta outflow is largely governed by the X2 regulatory requirements.

Predicted bromide concentrations at the North Bay Aqueduct are very low (generally less than 0.2 mg/L), indicating that the effects of salinity intrusion at this location are minimal (Figure 37). These projections are very similar to the No Action Alternative.

Nutrients

Conversion of agricultural lands to wetlands would likely decrease nutrient discharges which, coupled with improved circulation in the sloughs and rivers in the south Delta, should mitigate or prevent algal blooms and attendant low dissolved oxygen conditions.

Effects of Storage

Model predictions do not account for the effects of storage. The extensive storage elements of Alternative Variation 2E include 500 TAF of surface water storage in the San Joaquin River Region, 250 TAF of groundwater storage in the Sacramento River Region, 500 TAF of groundwater storage in the San Joaquin River Region, 3 MAF of storage in the Sacramento River Region, and 2 MAF of off-aqueduct storage. Preliminary DWRSIM modeling was conducted to evaluate the effects of surface storage on environmental flows and water supply. Details regarding the approach, assumptions, and limitations of the modeling are presented in the CALFED Bay-Delta Program System Operation Modeling Studies for Impact Team Analysis (DWR 1997d).

The effects of storage on water quality would depend on the size and location of the facilities, and operational considerations. Such facilities would improve water quality by redistributing flows from wet to dry months, and from wet to dry years. According to the modeling conducted, Alternative Variation 2E would increase total supply (environmental and consumptive) during critically dry years by 540 TAF/year, which is likely to significantly improve overall water quality during these years. As diversions to storage would be operated to capture unregulated flows when water quality is generally better, the diversions should not significantly degrade water quality.

Table 8 shows the assigned relative scores based on a comparison of predicted water quality with the No Action Alternative. In summary, significant water quality improvements are projected to occur for salinity at the Contra Costa Canal Intake and Clifton Court, and for bromide at the Contra Costa Canal Intake.

Alternative Variation 3E

Alternative Variation 3E involves extensive construction of surface storage facilities, new and expanded conveyance facilities, intake screens, and fish barriers. See the discussion concerning construction for Alternative Variation 2B.

Salts

This analysis indicates that Alternative Variation 3E will substantially improve the salinity conditions at Clifton Court Forebay as a result of the isolated facility. However, Alternative Variation 3E increases salinity at the other three locations.

Alternative configurations 3A, 3E, 3H, and 3I likely will have similar effects on salinity as Alternative Variation 3E. The alternative configurations isolate and convey Sacramento River water to the south Delta exports. These alternative configurations bring fresher water to the export pumps but reduce the amount of freshwater entering and flowing through the Delta.

Figures 38 through 40 show model predictions of TDS concentrations at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. The salinity at Contra Costa Canal Intake is predicted to range between 175 and 425 mg/L, with some improvement in TDS concentrations in June through September during critical years, and increased TDS concentrations in October through January for wet years. TDS concentrations at the Contra Costa Canal Intake are projected to be comparable to the No Action Alternative for wet water-year types. During critical years, predicted TDS would be more uniform throughout the year, resulting in predicted concentrations lower than the No Action Alternative in December through February, and higher than the No Action Alternative in March through July.

At Clifton Court, predicted TDS concentrations during wet years are consistently around 100 mg/L, which reflects the quality of the Sacramento River water delivered via the isolated facility. During critically dry years, predicted TDS concentrations occasionally would increase up to 200 mg/L, depending on the month. Predicted TDS concentrations at Clifton Court Forebay are generally comparable to the No Action Alternative during February through September and much lower (by as much as 200 mg/L) during October through January.

TDS concentrations at the North Bay Aqueduct are predicted to fall generally below 200 mg/L. These levels are essentially identical to predicted concentrations associated with the No Action Alternative.

Model simulations of Alternative Variation 3E indicated that DWR's contractual maximum monthly mean concentration of 440 mg/L at Clifton Court would not be exceeded during the 16-year simulated period.

Salinity intrusion was managed in the model (primarily by adjusting SWP exports) to meet the regulatory X2 requirements and other water quality and flow requirements as specified in the WQCP for San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995). Figure 4 shows the DWR model predictions of the mean maximum monthly X2 location in critically dry years for all the alternatives modeled. The values for Alternative Variation 3E from February through June (during which the X2 regulatory requirement applies) vary from 76.6 kilometers in February to 83.1 kilometers in May.

Under Alternative Variation 3E, there is a moderate improvement in salinity at Jersey Point, although not as large as for Alternative 2. During summer and winter, salinity is reduced by 10% or more, about 75% of the time. However, increases in salinity occur in all months except August and September.

Salinity at Emmaton appears to increase substantially under Alternative Variation 3E. Salinity increased by more than 10% in about 50% of the total months. Generally, increases would occur throughout the year. The few decreases that did occur were mostly in June.

Simulations of Alternative Variation 3E substantially increased salinities on Old River. There were about as many increases as there were decreases in salinity; however, the increases were greater in magnitude. Most of the increases occurred in winter and spring. Summer and fall showed a greater number of decreases in salinity.

Alternative Variation 3E appeared to improve salinity at Clifton Court substantially. Only a few increases in salinity occurred. The improvements in salinity occurred throughout the year.

Natural Organic Matter

Figures 41 through 43 show model predictions of DOC at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct. At the Contra Costa Canal Intake, the predicted concentrations range from 4 to 10 mg/L (Figure 41). For wet years, the peak concentration is about 10 mg/L whereas for critically dry years the peak concentration is about 8 mg/L. Predicted concentrations of DOC at Contra Costa Canal Intake were substantially higher compared to the No Action Alternative. For example, during critical years, predicted peak concentrations were about 10 mg/L compared to peaks of less than 8 mg/L for the No Action Alternative.

At the Clifton Court Forebay, predicted DOC concentrations were low (around 2 mg/L) throughout the year (Figure 42). Predicted concentrations at Clifton Court are substantially less (by as much as 2 to 3 mg/L) than under the No Action Alternative.

Predicted concentrations of DOC are substantially higher at the North Bay Aqueduct. Peak concentrations were about 14 mg/L during wet years. During critically dry years, predicted peak concentrations were about 8 mg/L (Figure 43). Predicted concentrations of DOC at the North Bay Aqueduct intake were very similar to the No Action Alternative.

The seasonal trends, with a peak around February, are generally consistent with DOC measurements from agricultural return flows, supporting the general contention that agricultural return flows are a major source of DOC in the Delta. The relatively high concentrations at the North Bay Aqueduct suggest that agricultural return flows make up a larger proportion of the source water at this location.

Bromide

Figures 44 through 46 show model predictions of bromide at the Contra Costa Canal Intake at Rock Slough, Clifton Court Forebay, and the North Bay Aqueduct Intake at Barker Slough. At the Contra Costa Canal Intake, predicted bromide concentrations during wet years were quite low (less than 0.2 mg/L), except during October through January, when they were 0.5 to 0.6 mg/L. Predicted wet year bromide concentrations at Contra Costa Canal Intake were substantially lower than the No Action Alternative in October through December, but otherwise comparable. During critically dry years, predicted concentrations showed less of a seasonal trend than the No Action Alternative. Therefore, predictions are lower than the No Action Alternative during July through January and higher from February through June.

Predicted bromide concentrations at Clifton Court were uniformly low (less than 0.1 mg/L) throughout the year. Predicted bromide concentrations at this location were much lower than concentrations under the No Action Alternative.

Predicted bromide concentrations at the North Bay Aqueduct Intake on Barker Slough, were low (generally less than 0.2 mg/L), indicating that the effects of salinity intrusion at this location are minimal (Figure 37). At this location predicted concentrations were very similar to those under the No Action Alternative.

Nutrients

Conversion of agricultural lands to wetlands would decrease nutrient discharges which, coupled with improved circulation in the sloughs and rivers in the south Delta, should mitigate or eliminate excessive algal blooms and attendant low dissolved oxygen concentrations.

Effects of Storage

Model predictions do not account for the effects of storage. The extensive storage elements of Alternative Variation 3E include 500 TAF of surface water storage in the San Joaquin River Region, 250 TAF of groundwater storage in the Sacramento River Region, 500 TAF of groundwater storage in the San Joaquin River Region, 3 MAF of storage in the Sacramento River Region, and 2 MAF of off-aqueduct storage. Preliminary DWRSIM modeling was conducted to evaluate the effects of surface storage on environmental flows and water supply. The effects of storage on water quality would depend on the size and location of the facilities, and operational considerations. Storage would improve water quality by redistributing flows from wet to dry months, and from wet to dry years. According to the modeling conducted, Alternative Variation 3E would increase total supply (environmental and consumptive) during critical dry years by 850 TAF/year—a substantial overall improvement in water quality during these years. Because diversions to storage would be operated to capture unregulated flows when water quality is generally better, the diversions should not significantly impair water quality when storage capacity is being filled.

Table 8 shows the scores that were assigned based on comparisons of predicted water quality with the No Action Alternative. In summary, the
significant changes based on this comparison are improved salinity, DOC, and bromide at Clifton Court, and improved bromide but poorer DOC at the Contra Costa Canal Intake.

Summary of TDS, Bromide, and DOC Consequences in Delta

Previous evaluations of the environmental consequences of specific actions on TDS, Bromide, and DOC have focused on how implementation of each alternative would potentially affect water quality at the seasonal (monthly) time scale relative to the No Action Alternative and existing conditions. In this section, the focus is on the differences amongst the alternatives in terms of overall water quality as indicated by the mean annual values. Comparisons are made only for those constituents modeled, namely TDS, bromide, and DOC.

BAY REGION

ALL ALTERNATIVES

Ecosystem Restoration Program

A series of programmatic actions are proposed for the Bay Region (Table 12). An initial screening was conducted to divide actions into two categories: those with minimal impacts on water quality and those with potentially significant impacts. Actions were judged to result in minimal impacts on water quality if they would not change the emission rate of pollutants or the concentrations of pollutants in waterbodies, or if the changes they would produce would be negligible. Two ecological zones in the Bay Region are addressed in the Ecosystem Restoration Program: Suisun Marsh and North San Francisco Bay.

Restore Tidal Perennial Aquatic Habitat and Tidal Emergent Wetlands

The acreage of shallow-water aquatic habitat and saline emergent wetlands would be increased by constructing setback levees and restoring tidal flow to 10,000 to 14,500 acres of land adjacent to Suisun Bay and Marsh, San Pablo Bay, the Napa and Petaluma rivers, and Sonoma Creek. The land to be converted currently is used for agriculture. Most of the aquatic habitat would consist of shallow open water with emergent vegetation around its margins.

Creation of aquatic habitat is discussed for this same action of the Ecosystem Restoration Program in the Delta Region. The action involves converting agricultural lands on the fringes of Suisun and San Pablo bays to aquatic habitat. The agricultural lands emit various substances that are discharged to the Bay. After implementation of this action, the created aquatic habitat would continue to emit substances, but the types and quantities would be different. Changes in the emission rates of metals, trace elements, and microbes are expected to be negligible and are not discussed further.

Natural Organic Matter

Much of the agricultural land bordering Suisun and San Pablo bays and the tidal reaches of tributary streams lies at elevations below the high tide stage and is separated from the Bay by levees. The agricultural land is of low quality and is used primarily for dry farming hay or as pasture. Little of the land is irrigated. Small acreages of pasture are irrigated where suitable water supplies are available. Excess runoff and irrigation water drain from the fields to perimeter ditches, which flow to sumps adjacent to the levees. Runoff and agricultural drainage water are pumped over the levees and into the Bay.

Conversion of land from agriculture to aquatic habitat in the Bay would change the rate of DOC emission as it would in the Delta (see earlier discussion of this action in the Delta Region). However, changes in DOC emissions to the Bay system are of little consequence because, even in Suisun Bay, Bay waters are too saline for use as drinking water supplies.

Pesticides

Pesticides are used sparingly on the agricultural lands adjacent to the Bay. Conversion of agricultural lands to aquatic habitat would eliminate the use of pesticides on the lands subject to this action and modestly reduce the discharge of pesticide-containing agricultural drainage water.

Salts

Conversion of agricultural land to shallow water aquatic habitat and saline emergent wetlands would have little effect on the emission of salts but could affect salt concentrations in the Bay. The evaporation rate from open water would be greater than that from a corresponding acreage of agricultural land. The increase in evaporation on the fringes of the north Bay would be unlikely to affect the salinity of Bay waters because the area involved in the land conversion would be small relative to the Bay's surface area.

Nutrients

Agricultural lands bordering the north Bay are not heavily fertilized as a rule; nevertheless, the conversion to wetlands would be expected to produce some reductions in nitrate emissions.

Restore Seasonal Wetlands

The acreage of seasonal wetlands would be increased by flooding agricultural lands for several months in winter and early spring. Small berms and other water control structures would be built so that water would be temporarily retained in shallow basins. The berms may be temporary or permanent. Water would be supplied primarily by rainfall and surface runoff. Approximately 7,000 acres of agricultural lands would be used as seasonal wetland. Pasture crops would be grown primarily, after the land was drained in early spring.

Action	Magnitude	Potentially Significant Environmental Impacts on Water Quality
Restore tidal perennial aquatic habitat and tidal emergent wetlands	10,000 to 14,000 acres	Yes
Restore tidally influenced channels and distributary sloughs	10 miles, 60 to 90 acres	No
Create deep open water in restored freshwater emergent wetlands	500 acres	No
Restore seasonal wetlands	7,000 acres	Yes
Restore riparian habitat	10 to 15 miles, 20 to 80 acres	Yes
Protect vernal pool habitat	500 to 1,000 acres	No
Restore perennial grasslands	1,000 acres	No

Table 12. Ecosystem Restoration Program Actions for the Bay Region

Seasonal wetlands may be created by simply delaying the pumping of water out of diked-off areas or by constructing small berms and dikes. Construction of berms and changes in land management would be the same as those discussed for this action in the Delta Region.

Natural Organic Matter

Converting agricultural lands to seasonal wetlands would likely increase the emission of natural organic matter (see discussion of this action in the Delta Region).

Pesticides

Pesticide emissions result from agricultural use of pesticides. The winter and spring use of agricultural land as seasonal wetlands would not alter agricultural activities for the remainder of the year. Pesticide emissions would not change.

Salts

As noted earlier, neither irrigated agricultural lands nor wetlands are net emitters of salts. However, the concentration of salts in various waterbodies may change as a result of altered evaporation rates.

Nutrients

The principal nutrient emitted by agricultural land is nitrate. Almost all of the nitrate is attributable to nitrogen fertilizers applied to croplands. Because crops would continue to be grown on the lands managed for seasonal habitat, nitrate emissions would not change.

Restore Riparian Habitat

Riparian vegetation and riverine aquatic habitat would be restored along the Napa and Petaluma rivers, Sonoma Creek, and waterways in Suisun Marsh and San Pablo Bay. Between 50 and 75 miles would be restored. Restoration procedures would depend on circumstances at a particular site. Restoration along stream reaches without levees or riprap would involve the clearing of non-native vegetation, minor regrading, and replanting with appropriate native species. Depending on the characteristics of the adjacent land use, the riparian areas may need to be fenced to exclude livestock.

Setback levees would be built behind existing levees, the existing levees demolished, and the materials used to create streamside benches on which riparian vegetation would be planted. Impacts would be similar to those described for this action in the Delta Region. The only water quality parameter directly affected would be temperature.

Water Quality Program, Including Coordinated Watershed Management

Reduce Heavy Metal Emissions in Mine Drainage

Drainage from abandoned mines may contribute heavy metals to San Francisco Bay. Numerous abandoned mercury mines exist in the Guadalupe River drainage, and they may be discharging metals to the south Bay. Metals emissions would be reduced by sealing mines, removing and capping tailings, and removing contaminated sediments from streambeds. Metal emissions would be reduced by 25 to 30%.

Impacts would be similar to those described for this action in the Sacramento River Region. Although the contribution of mine drainage to metals loadings in San Francisco Bay is not known, it is expected that metals concentrations in water and sediment in streams immediately below the inactive mines would decrease.

Reduce Emissions of Contaminants in Urban and Industrial Runoff

In the Bay Area, the following urban areas have prepared stormwater management plans and received stormwater discharge permits: Santa Clara County, Alameda County, Contra Costa County, San Mateo County, and the cities of Vallejo and Fairfield/Suisun. San Francisco was not required to prepare a stormwater management plan because the city does not have a separate storm drainage system; sanitary sewage and stormwater are collected in a single combined system. Characteristics of urban stormwater from Santa Clara County are shown in Table 13. Assumptions for the analysis of stormwater management actions were described for the Delta Region.

		Event Mean Concentration	
Constituent	**Unit**	**Wet Weather**	**Dry Weather**
Total Kjeldahl nitrogen	mg/L	1.8	1.3
Biological oxygen demand	mg/L	12.9	3.7
Turbidity	NTU	198	7.7
Oil and grease	mg/L	2.3	-
Total suspended solids	mg/L	336	9.3
Total organic carbon	mg/L	11.4	5.4
Total cadmium	mg/L	1.1	0.3
Total copper	µg/l	45.6	7.1
Total chromium	µg/l	36.0	3.4
Total lead	µg/l	49.2	1.4
Total mercury	µg/l	0.3	0.3
Total selenium	µg/l	0.3	1.9
Total zinc	µg/l	186	14

SOURCE:

Woodward-Clyde Consultants 1996.

Table 13. Typical Characteristics of Urban Runoff from Santa Clara County (Stream Stations)

Most stormwater management plans rely to a considerable degree on education and behavioral changes rather than on construction of new facilities. Where existing damaged systems are retrofitted with new stormwater treatment facilities, construction impacts similar to those associated with typical urban drainage projects would be expected. They could include temporary increases in soil erosion and sediment emission due to ground breaking.

In the Bay Region, metal loads from agriculture and abandoned mines are thought to be very small relative to those from urban and industrial stormwater runoff and M&I wastewater discharges. Urban and industrial runoff loads represent about 50% of the metal loads. Implementation of this action would decrease metal loads from urban and industrial runoff by about 10%, reducing total metal emissions to the Bay by about 5% compared to present conditions.

However, the population of the Bay Region is expected to grow from 6.1 million in 1997 to 6.9 million in 2020, an increase of approximately 13%. Assuming that new urban areas have the same average density as existing areas, the acreage of land devoted to urban uses and the emission of pollutants in urban runoff also would increase by 13%. Water quality would deteriorate in response to increased pollutant emissions, with the effects most noticeable near stormwater outfalls. Implementation of this action would reduce the rate of increase of pollutant emissions between 1997 and 2020. Pollutant emissions would increase by only about 3% rather than 13%. Thus, implementation of the Water Quality Program would improve water quality compared to the No Action Alternative.

Such a reduction would result in a minor beneficial effect on water quality, with the greatest effect in small streams of urban areas where flow consists primarily of urban runoff. Some benefits would be felt in the south Bay, where there is little water circulation in summer.

However, water quality would still deteriorate slightly relative to existing conditions.

Reduce Emissions of Contaminants from Wastewater Treatment Plant Discharges

This action and the assumptions used in the analysis are described for the Delta Region. Wastewater from refineries is a major source of selenium in the Bay Region. Enforcement of new rules for selenium discharges could produce considerable reductions in selenium loads to the Bay (above the 0 to 10% reduction in waste loads assumed in the analysis for M&I treatment plants). Construction activities and related impacts associated with this action also were described for the Delta Region.

Dischargers to San Francisco Bay with an average daily dry weather flow greater than 5 mgd include the Central Costa County Sanitary District, Central Marin Sanitation Agency, Delta-Diablo Sanitary District, East Bay Municipal Utility District, Fairfield-Suisun Sewer District, East Bay Dischargers Authority, Livermore-Amador Valley Water Management Agency, Napa Sanitation District, South Bayside System Authority, West County Wastewater District, and Vallejo Sanitation and Flood Control District; as well as the cities of Palo Alto, Sunnyvale, San Jose, South San Francisco, San Francisco, and San Mateo. The 13 major industrial dischargers include five petroleum refineries and six chemical manufacturers. The total average daily dry weather flow of municipal wastewater is about 550 mgd. The characteristics of wastewater effluent discharged by East Bay Municipal Utility District are shown in Table 14.

Constituent	*Unit*	**Mean Annual Concentration**
Biological oxygen demand	mg/L	18.7
Total suspended solids	mg/L	16.1
Total cadmium	μg/L	0.3
Total copper	μg/L	16.5
Total lead	μg/L	1.7
Total mercury	μg/L	0.06
Total selenium	μg/L	0.5
Total zinc	μg/L	76.3

SOURCE:

East Bay Municipal Utility District 1997.

Table 14. East Bay Municipal Utility District 1996 Effluent Quality

Compared to existing conditions, the 10% reduction in waste loads attributable to this action would improve water quality conditions close to the points of discharge, particularly in circumstances where the discharges are made to relatively quiescent receiving waters. The total metal load to San Francisco Bay would be reduced by only about 5% from the current load, producing little change in metal concentrations, especially in waters of the north and central Bay where tidal flushing is strong.

However, the population of the Bay Region is expected to grow from 6.1 million in 1997 to 6.9 million in 2020, an increase of approximately 13%. Assuming that the per capita emission of pollutants in wastewater remains constant and wastewater treatment levels remain the same, the emission of pollutants in wastewater discharges would increase by 13%. Water quality would deteriorate in response to increased pollutant emissions, with the effects most noticeable near wastewater outfalls. Implementation of this action would reduce the rate of increase of pollutant emissions between 1997 and 2020. Thus pollutant emissions from this source would increase by about only 3% rather than 13%. Although conditions would deteriorate slightly by 2020, relative to existing conditions, implementation of the Water Quality Program would still improve water quality compared to the No Action Condition. The beneficial effects of this action would occur in the extreme south Bay below Dumbarton Bridge, where no net outflow occurs during summer.

The potential for industry relocation as an indirect effect of this action was discussed for the Delta Region.

Relocate Diversions To Improve Water Supply Quality

In the Delta Region, this action described ways in which the water supply intakes in the Delta could be relocated to improve drinking water quality. In the Bay Region, numerous communities receive water from the Delta and would potentially benefit from this action. They include communities in Solano, Sonoma, and Marin counties that receive water from the North Bay Aqueduct; communities in Contra Costa County that receive water from the Contra Costa Canal; and communities in Alameda and Santa Clara County that receive water from the South Bay Aqueduct or the San Felipe Project.

There would be no short-term adverse impacts of this action. All construction activities would take place outside the Bay Region. The action would result in a long-term improvement in the quality of water diverted for municipal supply at certain times. The benefits would be greatest during periods of low Delta outflow, when brackish water from San Francisco Bay penetrates into the Delta and increases the salinity and bromide content of diverted water. The reduction in salinity would not be expected to have much effect on the health of consumers, although it could benefit some individuals on low-salt diets. It might improve the palatability of water to some consumers, but probably would not be noticeable to most. The reduction in bromide concentration would in turn reduce the concentration of THMs in finished water, with possible health benefits to consumers.

Improve Finished Drinking Water Quality by Treating Raw Water To Reduce Concentrations of Total Organic Carbon, Pathogenic Organisms, Turbidity, and Bromides

Surface waters are always treated before being served to customers. Conventional treatment for surface water from high-quality sources is simple disinfection. Conventional treatment for surface water from less-desirable sources consists of chemical coagulation, sedimentation, filtration and disinfection. However, since the passage of the Safe Drinking Water Act in 1974, drinking water standards have become increasingly stringent and, in some cases, conventional treatment is insufficient to meet the new standards.

Delta water always has been regarded by water purveyors as a less-satisfactory source of drinking water supply than water obtained from streams in the Sierra Nevada and its foothills. Delta water contains more dissolved mineral salts, dissolved organics, turbidity, and pathogenic organisms than water from Sierra streams. It is typically subjected to conventional water treatment before being served to customers. Conventional treatment reduces turbidity and virtually eliminates microbial organisms from the source water. There is little reason to add treatment processes to further reduce turbidity and pathogenic organism concentrations.

The new standards that are most problematic for water purveyors that obtain water from the Delta are those for DBPs. When water is chemically disinfected, the disinfection agents combine with dissolved organic matter to form various compounds, including THMs, which have been shown to cause cancer in animals. The EPA has established standards for THMs in finished drinking water and is likely to make the standards more stringent in the future. Because Delta waters contain relatively high concentrations of dissolved organic matter, they have a high THM-formation potential. The bromides that are present in Delta waters at certain times as a result of intrusion of brackish water from San Francisco Bay also contribute to THM formation and other potentially harmful DBPs, such as bromate.

The THM formation potential of Delta waters could be reduced by providing additional water treatment to remove some of the bromides and dissolved organic matter. Treatment processes that might be used for this purpose include carbon absorption, reverse osmosis, and ion exchange.

In the Bay Region, numerous communities receive water from the Delta. They include communities in Solano, Sonoma, and Marin counties that receive water from the North Bay Aqueduct; communities in Contra Costa County that receive water from the Contra Costa Canal; and communities in Alameda and Santa Clara counties that receive water from the South Bay Aqueduct or the San Felipe Project.

The only short-term adverse impacts of this action would be those associated with the construction of new treatment units at existing water treatment plants. Minor and local increases in sediment discharge could occur at construction sites but would be reduced by the application of conventional construction-impact mitigation measures.

No direct long-term adverse impacts on water quality would occur compared to the No Action Alternative. Indirectly, this action would increase the cost of water to consumers within municipalities served by the SWP and the CVP. This could alter patterns of water use, which could have indirect impacts on a number of environmental elements. Effects would be small in most cases because water costs are low compared to other costs incurred by residents and owners of businesses.

Storage and Conveyance

All Alternative Configurations

Management actions in the Delta and in the watersheds contributory to the Delta would affect San Francisco Bay because water from the Delta is the primary freshwater source to the Bay. The effects of all alternative configurations (except the No Action Alternative) on water quality in San Francisco Bay would be beneficial because the goal of system operations is to meet current SWRCB, EPA, and California Department of Health Services requirements and objectives. Many actions in the Water Quality Program address pollutant sources that discharge directly into the Bay or are present in the watershed contributory to the Bay.

Reservoir releases and pumping would be managed to ensure that Delta outflows are sufficient to meet the SWQCB salinity (X2) requirements from February through June. Salinity requirements also would be met at specific locations such as Suisun Marsh. Pollution prevention strategies (intended to be implemented alone or with watershed management initiatives) address mining, agriculture, and urban sources to control the loadings of metals, pesticides, pathogens, and other constituents and parameters of concern in San Francisco Bay.

Table 15 shows the modeled alternatives. For alternatives not modeled, the table indicates which modeling results would be most representative. Only conveyance features were modeled.

For Alternative configurations 3A, 3B, and 3H, the modeling results from Alternative Variation 3E are the only guide to the nature of possible water quality effects. However, because these alternatives call for a 5,000-cfs isolated facility rather than the 15,000-cfs isolated facility modeled in Alternative Variation 3E, the model predictions should be interpreted qualitatively (as indications of possible trends) rather than quantitatively.

SACRAMENTO RIVER REGION

ALL ALTERNATIVES

Ecosystem Restoration Program

Ecosystem Restoration Program actions proposed for the Sacramento River Region are listed in Table 16. The Ecosystem Restoration Program and initial screenings for significance were described for the Delta Region.

Restore Riparian Habitat

Riparian habitat would be restored by providing favorable conditions for growth of riparian vegetation, planting vegetation, constructing setback levees, acquiring conservation easements, modifying grazing and land management in riparian zones, modifying programs that remove woody debris from river channels, constructing artificial river channels, and controlling invasive exotic plants. Between 16,000 and 24,000 acres of riparian habitat would be restored on the Sacramento River. Approximately 200 miles of riparian corridor would be restored on Sacramento River tributaries, Mill and Deer creeks, and Cottonwood Creek.

Construction activities and emission rates associated with this action would be the same as those described for the Delta Region.

Temperature

Changes in water temperature depend on how much heat is received by a waterbody and the volume of water to be heated. Heat can be lost or gained by a variety of mechanisms; however, direct solar radiation influences stream temperatures more than evaporation, condensation, conduction, and convection. Maintenance of water temperature largely depends on the quantity and quality of streamside shade-producing vegetation. Planting and improving the conditions for growth of riparian vegetation would create more shade-producing vegetation and lower water temperatures. Lowered water temperatures would be most apparent in stream reaches with restored riparian corridors. Water temperatures would rise when the water surface is exposed again to solar radiation in downstream river reaches.

Dissolved Oxygen

The solubility of oxygen in water is directly related to water temperature. Oxygen solubility increases with decreasing water temperature. Water temperatures would decrease when shade-producing riparian vegetation was established; consequently, the dissolved oxygen level would increase. The increase in dissolved oxygen due to the temperature reduction may be offset somewhat by a decrease in dissolved oxygen due to the decomposition of organic matter emitted from the riparian zone.

Alternative Variation	Features	Modeled	If Not Modeled Most Representative Modeled Alternative Variation
1A	Re-operation	Yes	
1B	Re-operation CVPand SWP improvements	No	1C
1C	Re-operation CVP and SWP improvements South Delta improvements Up to 5 MAF added storage	Yes	
2A	North Delta improvements 10,000-cfs Hood Intake South Delta improvements	No	2B
2B	North Delta improvements 10,000-cfs Hood Intake South Delta improvements CVPand SWP improvements Up to 6.2 MAF added storage	Yes	
2E	Tyler Island habitat Mokelumne River floodway (East) East Delta habitat South Delta habitat CVP and SWP improvements Up to 6.5 MAF added storage	Yes	
3A	5,000-cfs open-channel isolated facility North Delta improvements South Delta improvements CVP and SWP improvements	No	3E
3B	5,000-cfs open-channel isolated facility North Delta improvements South Delta improvements CVP and SWP improvements Up to 6.7 MAF added storage	No	3E
3E	15,000-cfs open-channel isolated facility North Delta improvements CVP and SWP improvements Up to 6.7 MAF added storage	Yes	
3H	5,000-cfs open-channel isolated facility Tyler Island habitat Mokelumne River floodway (West) East Delta habitat South Delta habitat CVP and SWP improvements Up to 6.5 MAF added storage	No	3E

Table 15. Scope and Representativeness of Water Quality Modeling

Action	Magnitude	Potentially Significant Impacts on Water Quality
Restore riparian habitat	25,000 to 75,000 acres	Yes
Provide annual gravel replacement to improve spawning habitat	96,000 to 161,00 tons annually	Yes
Repair or rehabilitate spawning gravels on Mill and Cottonwood creeks	18 to 28 miles	Yes
Install fencing on Cow Creek to protect riparian vegetation	100,000 to 150,00 linear feet (2 to 4 acres)	No
Install fish screens on all diversions greater than 250 cfs, and two-thirds of all remaining diversions		No
Upgrade fish passage facilities at Anderson-Cottonwood Irrigation District, Red Bluff Diversion Dam, Big Chico Creek, and Lindo Channel		No
Prevent straying of adult salmon and steelhead by installing a rack at the mouth of Grover Diversion Canal		No
Preserve or restore floodplain and existing channel meander characteristics of Clear, Cottonwood, and Stony creeks	31 to 40 miles	Yes
Relocate M&I diversion from Big Chico Creek to the Sacramento River		No
Reconfigure Folsom Dam shutters to improve management of Folsom Reservoir's coldwater pool		Yes
Reconfigure Nimbus Dam turbine intakes to improve ability to regulate temperature of releases		Yes
Reduce temperatures in various rivers in Sacramento Basin, including Sacramento, Feather, Yuba, and Bear rivers		Yes

Table 16. Ecosystem Restoration Program Actions for the Sacramento River Region

Natural Organic Matter

Restoring riparian habitat includes acquiring conservation easements. It was assumed that some conservation easements would involve converting agricultural lands adjacent to stream channels to riparian habitat. Agricultural lands bordering stream channels in the Sacramento River Region are separated from the stream channels by levees. Runoff and agricultural drainage water is pumped over the levees and into stream channels. The presence of organic matter in the runoff and drainage return water in both dissolved and particulate form probably is attributable to the wash-off of organic matter from soils and crop residues, and from aquatic plants growing in the drainage ditches.

Converting land from agricultural use to riparian habitat would change the rate and type of organic matter inputs into stream channels. The organic matter inputs would change from those derived primarily from soils and crop residues to organic matter derived from trees, terrestrial herbaceous vegetation, and aquatic herbaceous vegetation in the riparian zone. Initially, organic matter inputs from the riparian zone would be less than the existing inputs from the agricultural land. As riparian biomass increased, greater amounts of organic matter would be emitted. It is not known whether the emission of organic matter from mature riparian zones would exceed that of the agriculture lands they would replace.

Pesticides

Rice is a major crop grown in the Sacramento Valley; as many as 500,000 acres are harvested each year (CVRWQCB 1991). The rice fields are flooded with irrigation water from the Sacramento River a few days before seeding in April or May. Pesticides may be incorporated into the soil before flooding or applied by air after flooding and seeding. Field water returned to the Sacramento River through the Colusa Basin Drain can contain rice pesticides. The maximum contribution of rice field discharge to the total flow of the Sacramento River is about 30% (SWRCB 1995).

Several pesticides are applied to rice in the Sacramento Valley; however, three pesticides of particular concern for water quality are molinate, carbofuran, and thiobencarb because of their potential adverse effects on striped bass larvae in the Sacramento River. Striped bass spawn between early May and mid-June, the time of greatest rice field drainage.

In 1990, the quantity of molinate (1,492,300 pounds) used on rice in the Sacramento Valley was more than 15 times greater than the quantity of carbofuran (88,240 pounds) or thiobencarb (95,830 pounds) (California Department of Pesticide Regulation 1990). Samples collected from the Colusa Basin Drain during May, June, and July 1990, 1991, and 1992 showed that the maximum concentrations of pesticides decreased each year as a result of a control program implemented by rice growers in cooperation with regulatory agencies (Crepeau et al. 1994). Converting agricultural lands to riparian habitat would eliminate the use of pesticides on the lands subject to this action and, thus, further reduce the discharge of pesticides to streams and rivers.

Pathogenic Organisms

This action includes improving management of livestock grazing to protect riparian vegetation and streambank stability. Exclusion of domestic animals and livestock from riparian areas and streams would reduce the direct release of animal fecal matter into streams and the discharge of runoff contaminated with fecal matter. Fecal matter contains many pathogenic organisms (organisms that can harm humans by infecting them). Restoring riparian habitat would reduce concentrations of pathogenic organisms in stream waters. Although most pathogenic organisms are effectively removed by conventional water treatment facilities, the risk of pathogens entering the domestic water supply is reduced when pathogen concentrations in raw water supplies are low. *Cryptosporidium*, a cyst-forming parasite that has caused several recent outbreaks of waterborne disease, also is thought to be carried by domestic cattle. Restoring riparian habitat would improve in-stream water quality and increase its suitability for municipal water supply and water-contact recreation.

Provide Annual Gravel Replacement To Improve Spawning Habitat

Gravel would be recruited to stream channels by exposing existing sources of river gravel on islands, bars, and banks that have become armored to river flows. Gravel would be stockpiled at locations where stream flows would move gravel into the stream channel. Additionally, removing or altering dams, acquiring or relocating existing gravel mining operations, adding gravel to stream channels, and reactivating and maintaining natural sediment transport processes may occur. Between 96,000 and 161,000 tons of gravel would be recruited to stream channels each year where necessary, to supplement natural gravel recruitment, maintain existing levels of gravel recruitment, and maintain average annual bedloads.

Stockpiling gravel at locations where it would be carried into stream channels would have little effect on water quality provided the gravel was prewashed to remove fine sands and silts. If silt was present but not removed, water turbidity would be increased. Exposing existing sources of gravel on islands, bars, banks, and other places where it is likely to contain a silt component would have greater, but localized, effects on water turbidity.

Some small diversion dams would be modified or removed to enable downstream movement of gravel that otherwise would be trapped behind the structures. Removing or altering existing dams could destabilize sediments that have accumulated behind them or upstream, and cause the possible downstream discharge of large quantities of gravels, sands, and silts. Although the downstream movement of gravels is generally desirable, the discharge of silt or sudden movement of large quantities of gravel could impair water quality by increasing water turbidity. Depending on the location and age of a dam, the accumulated sediments could be a reservoir of toxic substances, including metals from past mining activities, or agricultural pesticides that are resistant to chemical or biological degradation in the environment.

Depending on the height of the dam, some sediments may be left above the level of the new floodplain when the water level declines. However, because in most cases it would be impractical to remove sediments, downstream water turbidity would increase immediately after dams were removed or breached, and during the first few major storms. Eventually, conditions at the dam site would stabilize and turbidity levels would return to normal.

Gravel replacement would increase the downstream movement of gravel in rivers and streams. Downstream movement of finer materials also would be likely to increase, resulting in higher water turbidities, particularly during high flows. The action includes three activities (removing or altering dams, reactivating and maintaining natural sediment transport processes, and acquiring or relocating existing gravel mining operations) that could affect concentrations of constituents or parameters of concern. However, long-term significant changes in emission rates are expected to be negligible and are not discussed further.

Repair or Rehabilitate Spawning Gravels on Mill and Cottonwood Creeks

Spawning gravels in Mill and Cottonwood creeks would be rehabilitated by ripping to disturb armored streambeds, and by reactivating and maintaining natural sediment transport processes. Between 18 and 28 miles of stream channels would be treated using these techniques. Impacts would be the same as those described above for gravel placement.

Preserve or Restore Floodplain and Existing Channel Meander Characteristics of Clear, Cottonwood, and Stony Creeks

Floodplains would be acquired by direct purchase or easement from willing sellers. Stream channel meander characteristics would be restored by recontouring and regrading stream channels, controlling encroaching vegetation, and constructing setback levees. Between 31 and 40 miles of floodplains and stream channel meander areas in the Clear, Cottonwood, and Stony creek watersheds would be restored.

The effects of recontouring and regrading stream channels would depend on the construction methods used. Preferably, stream channels should be recontoured and regraded under dry conditions using earthmoving equipment. In this case, no discharge of sediment would occur during construction, but some increases in suspended solids concentrations and turbidity would occur when the new channels were exposed to stream flows. If excavation occurs in stream channels that contain water, localized turbidity and suspended solids concentration increases likely would occur.

Preserving or restoring floodplain and channel characteristics would involve converting agricultural lands to floodplains. Impacts associated with converting agricultural lands would the same as converting agricultural lands to riparian habitat, described earlier for restoring riparian habitat.

Restoring meander characteristics would increase the sinuosity of stream channels. Sinuosity is the ratio of stream length to valley length. The effect of increased sinuosity would be decreased streambank erosion and less discharge of suspended solids due to streambank erosion.

Water Quality Program, Including Coordinated Watershed Management

Reduce Heavy Metal Emissions in Mine Drainage

Drainage from inactive and abandoned mines has been identified as an important source of cadmium, copper, and zinc in the Sacramento River drainage. Major mines include Iron Mountain and Afterthought mines in the Redding area, Cherokee Mine in the Feather River drainage area, and Manzanita Mine on Cache Creek. Heavy metal emissions would be reduced by sealing mines, removing and capping tailings piles, diverting streams around metal sources, and removing contaminated sediments from streambeds. Metal emissions would be reduced by 25 to 30%.

The construction activities needed to reduce heavy metal discharges from inactive mines would vary from site to site depending on circumstances. However, considerable amounts of necessary earthwork can be anticipated. During and immediately following construction, soil erosion would be accelerated and sediment probably would be discharged to streams. Some temporary increases in metal discharges may occur due to the disruption of tailing piles and exposure of new surfaces to weathering.

Table 17 shows estimates of metal loadings to the waters of the Sacramento Valley below the major reservoirs from all sources. Reduction of cadmium, copper, and zinc emissions from inactive mines would reduce basin-wide loads by 15 to 25%.

Source	Cadmium	Copper	Zinc
Agriculture	0.65	41	88
Mine drainage	5	139	470
M&I wastewater	0.27	9	34
Urban runoff	0.58	24	131
Total	**6.5**	**213**	**723**

NOTES:

Information subject to revision.
Loads are for Sacramento River Basin below a major dam such as Shasta or Oroville.

SOURCE:
CALFED Water Quality Action Team 1997.

Table 17. Selected Metal Loads in Sacramento River Basin (thousands of pounds)

Metal concentrations in water and sediment could be expected to decline in the streams immediately downstream of the inactive mines. Because the behavior of dissolved and particulate metals in natural aquatic systems is complex, it is difficult to predict the consequences further downstream. Although high loads of metals enter the Sacramento River Region from inactive mines, only a fraction of the total load appears to enter the Delta. This may be because the metals form complexes with inorganic or organic substances, and accumulate or decay in the system upstream of the Delta. Alternatively, it may simply be an indication that measurement methods and the estimates based on them are flawed. In general though, it seems probable that this action would result in substantial reductions in metal concentrations in the Sacramento River and the Delta.

Reduce Emissions of Contaminants in Urban and Industrial Runoff

Urban stormwater runoff is a large-volume dilute waste stream. Stormwater runoff from urban areas typically contains higher concentrations of metals, suspended solids, nutrients, oil and grease, pesticides, and bacteria than runoff from undeveloped lands. Concentrations of some of these substances measured in runoff from the Sacramento area are shown in Table 18. Contaminants of concern found at elevated levels in surface runoff include cadmium, copper, zinc, nitrate, pathogenic microbes, and diazinon.

Until the 1980s, the discharge of stormwater runoff was essentially unregulated. In 1987, the Clean Water Act was amended to require permits for discharges of stormwater from urban and industrial lands to waters of the United States. Regulations promulgated by the EPA in 1990 required industries with the potential to generate contaminated stormwater, and cities with populations exceeding 100,000, to prepare stormwater management plans and apply for discharge permits. Draft regulations are being considered that would extend this program to cities with populations less than 100,000. Within the Sacramento River Region, Sacramento is the only city that has prepared a stormwater management plan and received a permit to discharge stormwater.

Municipal stormwater management plans prepared pursuant to the Clean Water Act typically rely on a number of BMPs to reduce the discharge of contaminated runoff. BMPs

Constituent	Unit	Event Mean Concentration: Wet Weather	Event Mean Concentration: Dry Weather
Ammonia (as N)	mg/L	0.59	0.45
Biological oxygen demand	mg/L	16	6.1
Nitrate	mg/L	1.63	1.36
Oil and grease	mg/L	2.3	< 0.5
Total phosphorus	mg/L	0.36	0.51
Total dissolved solids	mg/L	57	217
Total suspended solids	mg/L	84	9.4
Total cadmium	μg/L	0.63	0.27
Total chromium	μg/L	6.3	0.7
Total copper	μg/L	21	7.9
Total lead	μg/L	27	1.5
Total zinc	μg/L	159	61

SOURCE:

Larry Walker Associates 1996.

Table 18. Typical Characteristics of Urban Runoff from Sacramento Area

Industrial stormwater management plans similarly rely on BMPs to reduce the discharge of contaminated runoff. Typical industrial BMPs include storing materials under cover to minimize contact with rain, purchasing equipment and developing procedures for spill clean up, and routing washwaters to sanitary sewers rather than to storm drains.

This action involves the vigorous enforcement of current regulations which are, in effect, the stormwater management plans. It was assumed that future regulations would extend the stormwater management program to smaller cities, perhaps those with populations over 10,000. Economic penalties for noncompliance would be imposed, and incentives would be given for controls that exceed the minimum requirements.

As stated earlier, most stormwater management plans rely on education and behavioral change rather than construction of new facilities. Where existing drainage systems would be retrofitted with new stormwater treatment facilities, construction impacts similar to those associated with typical urban drainage projects can be expected. These impacts would include temporary increases in soil erosion, and sediment emissions due to ground breaking and erosion.

Because efforts to control pollutants in stormwater are in their infancy, it is difficult to judge their effectiveness. Where certain source controls (primarily programs to educate the public on the proper use of storm drains) have been in place for several years, the available data do not indicate any marked change in runoff quality. Although education can change human behavior, it is doubtful that the targeted human behaviors contribute greatly to the overall urban runoff pollutant load. It is, therefore, unlikely that programs emphasizing source controls and elimination of illicit connections would substantially reduce the emission of urban runoff contaminants. Most of the more significant pollutants in urban runoff are attributable to vehicle use, air pollutant fallout, pesticide use, and substances that are washed off buildings. Such sources are difficult to control and are largely unaffected by common, nonstructural BMPs.

Industrial source control measures are probably more effective than municipal source control measures for a number of reasons. Industrial sites are relatively small and, because they are controlled by a single owner, are easier to manage. Operating practices could be prescribed that minimize the generation of polluted runoff, and employees could be required to adhere to them. The processes that cause the generation of polluted runoff are also inherently easier to control than the processes in a city.

Provision of incentives may not be effective in encouraging a level of control of surface runoff pollutants that goes beyond existing regulatory requirements in developed areas. Incentives may be more effective in encouraging the implementation of surface runoff control measures in new developments. Units of government with authority over land use could encourage developers to incorporate additional surface runoff control measures into their projects by relaxing allowable density restrictions or providing other similar incentives.

Because of uncertainties regarding the effectiveness of current urban and industrial surface runoff controls and incentive-driven programs intended to enhance their effectiveness, an assumption was necessary to complete the impact assessment. It was assumed that aggressive enforcement of existing regulations, aggressive public education, and the proactive provision of incentives would result in the reduction of pollutant mass emissions from urban and industrial runoff from developed areas by 5% and from undeveloped areas by 20%. For planning and assessment purposes, an average reduction of 10% was assumed for the comparison to No Action Alternative conditions.

Table 17 shows estimated cadmium, copper, and zinc loads from all sources in the Sacramento River Region. The proportion of the cadmium load attributable to urban and industrial runoff is about 9%. Corresponding proportions for copper and zinc are 11 and 18%, respectively. Implementation of this action and a consequent reduction in metal loads from urban and industrial runoff of about 10% would have little effect on basinwide metal loads, and water and sediment quality and would probably only slow the rate of increase. However, it could have a minor beneficial effect on water quality in small streams in urban areas.

An area where more vigorous enforcement of existing regulations could be effective is the control of sediment discharges from construction sites. Numerous investigators have indicated that construction sites are an important source of sediment discharge in urban areas (Washington Area Council of Governments). Most stormwater management plans call for the application of BMPs to control erosion at construction sites. Compliance is often imperfect because cities and counties lack the staff to conduct the appropriate inspections. A reduction in sediment loads would benefit water quality in small streams in urban areas, but would have little impact on regional suspended solids loads and water turbidity. At a regional scale, water turbidity associated with construction probably would be insignificant relative to turbidity associated with agriculture.

The small decrease in nutrient loads in urban and industrial runoff attributable to this action would be unlikely to have much effect on regional water quality. Nutrient loads from agriculture dwarf those from urban areas. Similarly, small decreases in emissions of microbiological contaminants in urban runoff are unlikely to have much effect on regional water quality.

Most stormwater monitoring studies report that pesticides are not detected at the part per billion (ppb) level. In recent years, however, researchers have noted that certain pesticides commonly used in urban areas can cause toxic effects on aquatic life at concentrations less than 1 ppb. Analyses of urban runoff using detection limits below 1 ppb often detect diazinon and, less frequently, chlorpyrifos. Because education programs regarding the use of pesticides are commonly a part of urban stormwater plans, some minor reductions in pesticide emissions could be expected from implementation of this action. The 10% reduction assumed above for other stormwater elements probably would be reasonable. This reduction would produce minor benefits in urban streams but would have little effect on downstream waters. The mass emission of pesticides from urban areas would be small compared to that from agriculture.

The population of the Central Valley is expected to grow from 4.6 million in 1997 to 7.2 million in 2020, an increase of approximately 60%. Assuming that new urban areas have the same average density as existing areas, the acreage of land devoted to urban uses and the emission of pollutants in urban runoff also will increase by 60%. Water quality would deteriorate in response to increased pollutant emissions, with the effects most noticeable near stormwater outfalls. Implementation of this action would reduce the rate of increase of pollutant emissions between 1997 and 2020. Pollutant emissions would increase only by about 40%, rather than 60%. Thus, implementation of the Water Quality Program would improve water quality compared to the No Action Alternative. However, water quality would still deteriorate relative to existing conditions.

In circumstances where urban runoff discharges cause violations of in-stream standards, regulatory agencies may require higher levels of control to counteract population-driven declines in water quality. It is not clear whether practical urban stormwater control measures capable of reducing pollutant loads by 50% or 60% are available.

Reduce Emissions of Contaminants from Wastewater Treatment Plant Discharges

Untreated M&I wastewater contains many elements of concern, including metals and trace elements, natural and synthetic organic chemicals, salts, nutrients, and suspended solids. The federal Clean Water Act requires that all M&I wastewater receive at least secondary treatment before it is discharged to the waters of the United States. Secondary treatment of municipal wastewater removes about 85% of the biochemical oxygen demand and TSS in the wastewater, and smaller proportions of metals, trace elements, and nutrients. Higher levels of treatment are required if the application of secondary treatment does not result in compliance with in-stream water quality standards.

Certain substances that are not removed very effectively in municipal wastewater treatment plants are addressed by pretreatment programs. Pretreatment programs seek to minimize the discharge of toxic metals to the municipal wastewater collection system by requiring industries that discharge to the sewer to reduce the concentrations of offending substances before they enter the municipal sewer. Pretreatment programs have been relatively successful in reducing the metal content of treated municipal wastewater discharges.

This action would vigorously enforce existing regulations affecting wastewater discharges—in effect the effluent limits and the pretreatment requirements—and provide incentives to encourage reductions in pollutant discharge that exceed current regulations. One possible approach would be to provide incentives for wastewater reclamation and reuse that would reduce the discharge of pollutants to surface waters.

It is expected that the effectiveness of this action would be limited. Unlike the urban runoff control program described above, the program to control M&I wastewater is mature, having been in place for more than 20 years. The RWQCBs already vigorously enforce the effluent limits they place on dischargers. It is not clear that even more vigorous enforcement of effluent limits would yield any useful results, although some improvements might result from more vigorous enforcement of pretreatment programs by dischargers themselves. It is also not clear how incentives could be provided to encourage further pollutant discharge reductions. For this assessment, it was assumed that implementing controls on M&I wastewater would result in a 0 to 10% reduction in waste loads from M&I treatment plants, with the high end of the range assumed for this analysis.

Any construction activities associated with reducing emissions of contaminants would be concentrated at municipal wastewater treatment plants and at industrial facilities. The acreage of land disturbed by construction would be small. The relatively minor environmental impacts of construction activities could be further lessened by the incorporation of commonly applied construction mitigation measures. These would include erosion control measures to prevent the discharge of sediments from disturbed lands, and measures to insure the proper storage and handling of fuel and construction materials.

Because the Sacramento Valley is lightly populated, there are only a few large municipal wastewater discharges. Dischargers with an average daily dry weather flow greater than 1 mgd include the cities of Sacramento, Red Bluff, Redding, Marysville, Yuba City, Oroville, and Chico. The measured characteristics of Sacramento wastewater effluent are shown in Table 19. The total average daily dry weather flow of municipal wastewater is 200 mgd, of which about 75% comes from Sacramento (Montoya et al. 1988). Emission reductions attributable to Alternative 3 and upstream of Sacramento would be felt close to the points of discharge, and would result in minor water quality improvements. Because of the small volume and wide distribution of the municipal wastewater loads, there would be little effect on regional water quality. The reduction in emissions from Sacramento would have a greater effect, particularly during low river flow periods, because of the volume of the discharge. A minor improvement would occur in the reach of the Sacramento River below the discharge.

The population of the Central Valley is expected to grow from 4.6 million in 1997 to 7.2 million in 2020, an increase of approximately 60%. Assuming that the per capita emission of pollutants in wastewater remains constant and

Constituent	Unit	Concentration
Oil and grease	μg/L	1,700
Total cadmium	μg/L	0.33
Total copper	μg/L	17
Total lead	μ g/L	2
Total mercury	μg/L	0.02
Total zinc	μg/L	91

SOURCE:

Montoya et al. 1988.

Table 19. Sacramento Regional County Sanitation District Effluent Quality

wastewater treatment levels remain the same, the emission of pollutants in wastewater would increase by 60%. Water quality would deteriorate in response to increased pollutant emissions with the effects most noticeable near wastewater outfalls. Implementation of this action would reduce the rate of increase of pollutant emissions between 1997 and 2020. Pollutant emissions would increase by about 50% rather than 60%. Thus, implementation of the Water Quality Program would improve water quality compared to the No Action Alternative. However, it would still deteriorate relative to existing conditions.

Such deterioration in water quality as a result of population growth is likely to be unacceptable to regulatory agencies. In many cases, regulatory agencies would impose more stringent effluent limits to maintain compliance with in-stream standards. Municipalities and industries would have to increase treatment levels in order to meet the standards.

A potential indirect effect of vigorous enforcement of effluent limits and pretreatment requirements is industry relocation. If wastewater management costs for industries increased, they may choose to relocate to areas where wastewater treatment costs are less. The environmental impacts of wastewater disposal would then be transferred from one place to another. Any indirect impacts of this action would be expected to be minor because the action itself is minor in that it does not call for more stringent standards, only enforcement of those that already exist.

Reduce Emissions of Contaminants in Agricultural Surface Runoff

The regulations applicable to discharges of agricultural runoff and measures that can be taken to reduce contaminant emissions in runoff are discussed under "Reduce Emissions of Contaminants in Urban and Industrial Runoff" for the Water Quality Program in the Sacramento River Region. Also refer to the discussion of "Reduce Emissions of Contaminants in Agricultural Surface Runoff" for the Delta Region and "Mitigation Strategies."

The effects of the reduction in contaminants discharged in agricultural runoff would primarily benefit water quality in drainage channels and streams within, or close to, agricultural lands. However, because about 12% of the land in the Sacramento River Region is in irrigated agriculture, the total reduction in contaminant loads could be quite large.

Reduce Discharge of Pathogens from Recreational Vessels by Enforcement of Existing Regulations and Provision of Incentives

Regional impacts would be the same as those in the Delta Region. Specifically, the impacts of pathogens from this source on water quality at various water system intakes in the region, including those of the City of Sacramento on the Sacramento and American rivers, would be reduced.

Upstream Surface Water Storage North of the Delta in the Sacramento Valley

Storage north of the Delta would be filled with water during periods of high streamflow, usually during the spring. Water would be released to the Sacramento River or to satisfy irrigation demands during low flow periods, usually during late summer or fall. CALFED alternatives contain from 0 to 3 MAF of upstream surface water storage that could be used in this manner, north of the Delta.

Water quality impacts would result from reservoir construction activities. Most impacts would be associated with ground disturbances and would result from increases in erosion rates. The extent of ground disturbance would depend on the type of dam construction employed and the need for construction of new roads to access the reservoir sites. Concrete dams are less massive than earthfill dams and thus require less excavation to build.

Excess sediment could be discharged to streams as a result of construction activities conducted directly in streambeds, and as a result of precipitation falling on exposed soils. Construction of dams and related facilities would occur almost completely in dry conditions. When a dam is built on a stream, the stream is typically diverted around the active construction area. Also, for practical reasons, much of the ground-disturbing earthwork would be scheduled for the dry season. Increased rates of soil erosion are likely to occur during the rainy season in areas that have been disturbed by construction.

Storage of water in reservoirs may affect water quality in a number of ways. The reservoir pool would cover previously dry lands. Depending on geologic characteristics, trace elements in submerged soils and rocks may be mobilized, particularly in the deeper parts of the reservoirs where dissolved oxygen concentrations may become depressed. Mercury is present in some parts of the Sacramento Valley. If anaerobic conditions occur in the bottom sediments of reservoirs, methyl mercury, a biologically available form of mercury, may be formed as a result of bacterial action. These conditions can be reduced by clearing vegetation from the area before the reservoir is filled.

Upstream reservoirs in the Sacramento River Basin would typically store abundant spring flows for later release and use in dry months or years. Onstream and offstream reservoirs would alter the hydrology of the streams below the dams. Springtime flows would be reduced compared to unimpaired flows, and flows during naturally dry periods would be increased. Because reservoirs trap sediment, the TSS content of water released into downstream channels would be less than the content prior to reservoir construction. The reduction in sediment loads would be greatest during high-flow conditions. Nutrients, and portion of total organic carbon (TOC) that is associated with particulates, also may be trapped in the reservoir, and their concentrations downstream reduced compared to preproject conditions.

Depending on the design of the reservoir outlet facilities, the dissolved oxygen content of released water could be less than that of pre-reservoir stream water. Conversely, when the reservoir is spilling, water may become supersaturated with oxygen and nitrogen. High levels of dissolved nitrogen can be dangerous to fish.

In situations where the unimpaired stream flows are low, the release of larger flows of water from reservoirs could substantially reduce water temperatures in downstream river reaches. Water released from reservoirs would be initially cooler than unimpaired stream flows, and would remain cooler due to the greater volume of flow.

Conveyance Components North of the Delta

Conveyance facilities north of the Delta would be used to move water into storage in new and enlarged reservoirs, and to release it back to streams and canals. The conveyance components include new canals and tunnels with capacities between 5,000 and 10,000 cfs, and the enlargement and extension of the existing Tehama-Colusa Canal.

Most impacts from tunnel and canal construction activities would be associated with ground disturbance and would result from increases in erosion rates. The extent of ground disturbance would depend on the type of construction employed and the need for construction of new roads to access the tunnel and canal sites. The areal extent of ground disturbance associated with tunnel construction would be small compared to that of canal construction.

Ground disturbances associated with tunnels would be limited to a few acres in the vicinity of the tunnel portals and the materials disposal sites. Canal construction would produce ground disturbances along the entire length of the canal. However, most construction activities would occur in dry conditions away from waterways. Exceptions could occur at locations where a canal must cross a stream, although in these cases the stream would typically be diverted around the construction activities. The much larger wet season discharges typically would be conveyed under canals in large conduits.

For practical reasons, much of the ground-disturbing earthwork would be scheduled for the dry season. Little precipitation-related soil erosion would occur during construction, but increased rates of soil erosion are likely to occur in disturbed areas during the rainy season following construction.

The disposal of tunneling materials could affect water quality. Broken rock obtained from subsurface strata may contain metals that can be mobilized when the rocks come into contact with precipitation. Metals could then drain to streams and rivers just as they do from abandoned mining sites.

Impacts of conveyance facilities north of the Delta cannot be separated from those of surface storage north of the Delta.

Groundwater Storage North of the Delta

Groundwater storage north of the Delta in the Sacramento Valley would be used with surface waters to meet various needs and demands for water. During high-streamflow periods, groundwater aquifers with available space would be recharged with excess surface water using spreading basins or injection wells. Water would be pumped from the aquifers to meet irrigation demands during low-streamflow periods.

The alternatives contain up to 250 TAF of groundwater storage north of the Delta. Nine potential sites for groundwater storage have been identified. Their total estimated storage capacity is 4.1 MAF.

Construction activities associated with development of groundwater storage using injection wells would involve little ground disturbance and would have few short-term impacts on water quality. Ground disturbances associated with constructing spreading basins would be greater. However, because construction would generally occur in areas with little topographic relief, control of soil erosion would be relatively straightforward, and any impacts on water quality would be minimal.

The quality of water diverted from surface streams, temporarily stored in the ground, and then returned to streams, would be altered. Water returned to the stream would contain less particulate matter and more dissolved substances than the source water. Percolation or injection into the ground would remove sediment and organic particles. Passage through soil and rock layers would increase the mineral content of water.

The release of water from groundwater storage into surface streams during periods of low streamflow would have similar effects to the release of water from surface reservoirs.

SAN JOAQUIN RIVER REGION

ALL ALTERNATIVES

Ecosystem Restoration Program

The Ecosystem Restoration Program actions proposed for the San Joaquin River Region are listed in Table 20. Program in the Sacramento River Region, but on a much smaller scale.

Restore Riparian Habitat

A total of 100 miles of riparian corridor would be restored on the San Joaquin, Stanislaus, Tuolumne, and Merced rivers. Because this action does not include any construction activities, water quality would not be affected by construction. Impacts of restoring riparian habitat would be similar to those described for this action in the Sacramento River Region, but on a considerably smaller scale.

Action	Magnitude	Potentially Significant Impacts on Water Quality
Restore or improve management of riparian habitat	1,500 to 5,000 acres	Yes
Provide annual gravel replacement to improve spawning habitat	12,000 to 25,000 tons annually	Yes
Install or improve fish screens on the North San Joaquin Conservation District diversion and at Woodbridge Dam		No
Prevent straying of adult salmon and steelhead by installing a temporary weir on the San Joaquin River upstream from the confluence with the Merced River		No
Preserve or restore floodplain and existing channel meander characteristics	33 to 56 miles	Yes
Restore perennial aquatic habitat	1,000 acres	Yes
Restore seasonal wetland habitat	3,000 acres	Yes
Reduce water temperatures on lower Merced, Tuolumne, and Stanislaus rivers	3,000 acres	Yes

Table 20. Ecosystem Restoration Program Actions for the San Joaquin River Region

Provide Annual Gravel Replacement To Improve Spawning Habitat

Between 12,000 and 25,000 tons of gravel would be recruited to stream channels each year where necessary to supplement natural gravel recruitment, maintain existing levels of gravel recruitment, and maintain average annual bedloads. Impacts of this action would be the same as those described for the Water Quality

Preserve or Restore Floodplain and Existing Channel Meander Characteristics

Impacts would be the same as those described for the Ecosystem Restoration Program in the Sacramento River Region ("Preserve or Restore Floodplain and Existing Channel Meander Characteristics of Clear, Cottonwood, and Stony Creeks").

Restore Perennial Aquatic Habitat

The acreage of perennial aquatic habitat would be increased by constructing setback levees, by flooding islands, and by connecting dead end sloughs to Delta channels. Approximately 3,000 acres of agricultural land would be converted to aquatic habitat. Most of the aquatic habitat would consist of shallow open water with emergent vegetation around its margins.

Activities involved in creating aquatic habitat were described for the Ecosystem Restoration Program in the Delta Region under "Restore Tidal Perennial Aquatic Habitat and Tidal Emergent Wetlands." Impacts would be similar to those described for the Delta, but on a much smaller scale.

Much of the agricultural land bordering the San Joaquin River and its tributaries is separated from the streams by levees. Excess runoff and irrigation water drains from fields to perimeter ditches. Water in the perimeter ditches may be pumped over the levees into the adjacent channels or may flow to a network of agricultural drainage channels that ultimately discharge into the San Joaquin River. In parts of the San Joaquin Valley, high water tables make subsurface drainage of cropland a necessity. Subsurface drainage water is routed to open channels at the perimeter of fields and then to the San Joaquin River.

Converting agricultural lands to aquatic habitat would alter the emission rate of various substances to the San Joaquin River and its tributaries. Currently, discharges from agricultural lands contain salts, organic carbon, nutrients, microbes, and traces of pesticides. Following implementation of this action, the created aquatic habitat would continue to emit various substances, but their types and quantities would be different. Changes in emissions of metals and trace elements other than selenium are expected to be negligible and are not discussed further. None of the changes would have much effect on regional water quality because this action would affect less than 1% of the agricultural land in the San Joaquin Valley.

Natural Organic Matter

Agricultural drainage water in the San Joaquin Valley is relatively rich in organic matter. The organic matter is in dissolved and particulate forms, and is probably attributable to dissolution and wash-off of organic matter from soils and crop residues. Conversion of agricultural lands to aquatic habitat could increase or decrease the mass emission of natural organic matter to waterways, which could in turn affect the cost of treatment if river water is used as a source of drinking water (see "Restore Tidal Perennial Aquatic Habitat and Tidal Emergent Wetlands" in the Delta Region for further discussion of this issue).

Pesticides

Various pesticides are used on agricultural lands in the San Joaquin Valley. Irrigated agriculture is presently the most prevalent land use in the San Joaquin Valley. In 1990, 428 different pesticides with a combined active ingredient weight of about 28 million pounds (DWR 1990b) were applied to a wide variety of crops, including grapes, stone fruit, field crops, truck crops, and some rice. Pesticides are discharged into waterways via surface runoff from cropland and subsurface drainage.

Agricultural drainage in the San Joaquin Basin consists of surface runoff and subsurface drainage. Surface runoff is discharged directly into the lower reaches of the east side streams, west side streams, and the San Joaquin River. Subsurface drainage is common on the west side of the San Joaquin Basin, where near-surface clays restrict percolation and cause high water table conditions. During the irrigation season, typically April to October, 40 to 45% of the flow in the San Joaquin River may consist of surface and subsurface agricultural drainage (CUWA 1996).

The CVRWQCB monitored toxicity in five agricultural drains from 1991 to 1992 (Foe 1995). Chlorpyrifos was detected 55% of the time from drains on both sides of the valley. Chlorpyrifos is used on walnuts, almonds, apples, and corn, as well as other crops. Diazinon was detected 65% of the time in drainage water as indicated in Table 21 (Foe 1995). Diazinon is used on almonds, melons, tomatoes, peaches, apricots, and walnuts. Carbaryl was detected 4% of the time in samples from the west side of the valley only. It is a foliar spray that is used on almonds, beans, corn, grapes, peaches, and tomatoes.

Pesticide	Frequency of Detection	Number of Detections	Range (μg/L)
Diazinon	65.4	178	0.01 to 2.60
Chlorpyrifos	55.2	150	0.01 to 1.60
Carbaryl	3.6	6	0.06 to 8.4

SOURCE:

Foe 1995.

Table 21. Pesticide Detections in the San Joaquin River Region, 1991 to 1992

Salts

When water is applied to agricultural land, some evaporates, some is used by crops, some runs off the surface of the land, and some percolates into the ground. Farmers must apply sufficient water to the land to flush the salts contained in the applied water out of the superficial soil layers. To do otherwise would allow salt to build up in the soil, with consequent adverse effects on crop yields or the type of crops that can be cultivated.

In the San Joaquin River Region, little runoff of applied water occurs; most of the water not evaporated or used by plants percolates into the ground and is drained to ditches at the perimeter of the fields from which it flows, or is pumped back into waterways tributary to the San Joaquin River. The volume of drainage water is currently estimated to be 25 to 50% of the volume of applied water. It is further estimated that the average salt content of drainage water is two to four times greater than that of the applied water (Jones & Stokes Associates 1995).

If agricultural land was converted to shallow-water perennial aquatic habitat, croplands would be replaced by open water with a fringe of emergent wetlands. The created aquatic habitat would neither take up nor emit salts. Thus, the change in land use would have no effect on the emission of salts. It would, however, result in increased salt concentration in waterways. The evaporation rate from open water would be greater than the evaporation rate from the corresponding acreage of agricultural land.

Nutrients

The principal nutrient in agricultural drainage water is nitrate. Phosphorus tends to become bound up in the soil and ammonia is converted to nitrate by nitrifying bacteria in the soil. Nitrate levels in agricultural drainage water are high; concentrations are 25 to 50 times higher than in typical uncontaminated surface waters. Almost all of the nitrate is attributable to nitrogen fertilizers applied to croplands.

Conversion of agricultural lands to perennial aquatic habitat would reduce nitrate emissions. Plants in the newly created aquatic habitat would use nutrients during the growing season and release them in the form of organic nitrogen as plants die and decay. Unlike agricultural land, the aquatic habitat would not be a net exporter of nitrogen.

Selenium

Agricultural drainage water from the western San Joaquin Valley contains high concentrations of selenium. Drainage waters from this area are primarily discharged to the San Joaquin River through Mud and Salt sloughs. If any agricultural lands in this area were converted to aquatic habitat, the mass emission of selenium to the river would be reduced in proportion to the percentage of the source area converted.

Restore Seasonal Wetland Habitat

Approximately 1,000 acres of agricultural lands would be used as seasonal wetlands. Crops would be grown after the land is drained in early spring. Refer to "Restoring Seasonal Wetlands" discussed for the Ecosystem Restoration Program in the Delta Region. Impacts on natural organic matter, pesticides, salts, and nutrients would be similar to those discussed for the Delta Region, but on a much smaller scale.

Water Quality Program, Including Coordinated Watershed Management

Reduce Heavy Metal Emissions in Mine Drainage

Drainage from inactive and abandoned mines has been identified as a source of heavy metals in the San Joaquin River drainage. The principal mine in the basin is the New Idria Mine in San Benito County. Heavy metal emissions would be reduced by sealing mines, removing and capping tailings piles, diverting streams around metal sources, and by removal of contaminated sediments from streambeds. Metal emissions are expected to be reduced by 25 to 30%.

Impacts would be the same as those described under the Water Quality Program for the Sacramento River Region.

Data on metal loads from all sources in the San Joaquin Basin are incomplete; the available estimates are shown in Table 22. Because mine drainage does not appear to be a very significant source of cadmium or copper, a reduction of 25 to 30% would not have much effect on total loadings to the basin.

Source	Cadmium	Copper	Mercury
Mine drainage	0.01	0.2	0.002
M&I wastewater	0.20	NK	NK
Urban runoff	0.19	9	NK
Total	0.4	9.2	0.002

NOTE:

NK = Not known.

SOURCE:
CALFED Water Quality Action Team 1997.

Table 22. Selected Metal Loads in San Joaquin County (thousands of pounds/yr)

In general, it seems probable that this action would result in a minor reduction in metal concentrations in the San Joaquin River and the Delta.

Reduce Emissions of Contaminants in Urban and Industrial Runoff

In the San Joaquin River Region, the only urban area that has prepared a stormwater management plan and received a stormwater discharge permit is the City of Modesto. The characteristics of urban stormwater runoff in Modesto are shown in Table 23. Impacts would be similar to those described for Water Quality Program in the Sacramento River Region.

Urban and industrial runoff loads probably represent a considerable proportion of total metal loads in the San Joaquin River Region. Implementation of this action would decrease metals loads from urban and industrial runoff by about 10% compared to the No Action Alternative. However, increased loadings generated by growth projections of 60% would more than negate the reduction. Thus, the action would only slow down the rate of increase from present levels, and pollutant emissions would increase by about 40% rather than 60%.

Constituent	Unit	Event Mean Concentration[a]
Total suspended solids	mg/L	201
Biological oxygen demand	mg/L	145
Total copper	μg/L	45
Total lead	μg/L	38
Total zinc	μg/L	377
Total petroleum hydrocarbons	μg/L	1,000
		Range[b]
Diazinon	μg/L	0.056 - 1.0
Chlorpyrifos	μg/L	0.03 - 0.25

NOTES:

a Data collected at Bodem Street Manhole. Concentrations are average values for three sampling events between 1993 and 1995. Concentrations represent first flush conditions.

b Range of concentrations from U.S. Geological Survey monitoring of five Modesto urban runoff sites.

SOURCE:
Archibald & Wallberg Consultants 1996.

Table 23. Characteristics of Urban Stormwater Runoff in Modesto

Such a reduction would have a minor beneficial effect on water quality, with the greatest effect felt in small streams of urban areas where the flow consists primarily of urban runoff.

Reduce Emissions of Contaminants from Wastewater Treatment Plant Discharges

Dischargers with an average daily dry weather flow greater than 1 mgd in the San Joaquin Valley include the cities of Modesto, Turlock, Ceres, Merced, and Atwater. The total average daily dry weather flow of municipal wastewater is about 35 mgd. The characteristics of Modesto's wastewater effluent are shown in Table 24. The 10% reduction in waste loads attributable to this action would improve water quality conditions close to the points of discharge compared to the No Action Alternative, particularly where the discharge represents a substantial proportion of the flow in the receiving water. However, the action would have little effect on regional water quality conditions and it would result in only a reduction of the projected increase in emissions from this source, and slowing down the rate of increase. Ultimately the increase would be reduced from 60% to 50% as a result of this action.

Reduce Emissions of Contaminants in Agricultural Surface Runoff

The general characteristics of agricultural surface runoff, applicable regulations, and various control strategies are described for the Water Quality Program in the Sacramento River Region. Impacts would be similar to those described for the Sacramento River Region. The effects of reductions in contaminant discharge in agricultural runoff would primarily benefit water quality in drainage channels and streams win or close to agricultural lands. An area-wide reduction in pesticide emissions of 20% would result in a substantial reduction in contaminant loads, because about 20% of the land in the San Joaquin River Region is irrigated agriculture.

Reduce Emissions of Contaminants in Agricultural Subsurface Drainage

Much of the irrigated agriculture in the San Joaquin Valley supplied with water from the Delta is located west of the San Joaquin River. Groundwater levels are high as a result of many decades of irrigation and soil conditions that do not lend themselves to deep percolation. Soils in the area were derived from marine sediments and are high in salts and trace elements. Excess water and salts must be drained away from the root zone for the land to remain productive.

Constituent	Unit	Monthly Average Concentration (January)	Monthly Average Concentration (May)
Total suspended solids	mg/L	41	32
Biological oxygen demand	mg/L	9.4	10.2
Oil and grease	mg/L	3.90	3.15
Ammonia (as N)	mg/L	0.37	0.16
Organic N	mg/L	12.3	9.6
Nitrate (as N)	mg/L	0.06	0.22
Orthophosphate	mg/L	1.88	2.56
Conductivity	μmhos/cm	1,298	1,020

SOURCE:

City of Modesto, Public Works & Transportation Department, Industrial Waste Division 1997.

Table 24. City of Modesto Water Quality Control Facility 1996 Effluent Quality

This is accomplished by subsurface drainage, which may occur passively by percolation to deep drainage channels at the perimeter of fields, or actively enabled by the installation of tile drains. Drainage water contains high concentrations of salts and trace elements as shown in Table 25. Disposal of subsurface agricultural drainage water has been a problem in the San Joaquin Valley for many decades.

Characteristic	Unit	Minimum	Median	Maximum
pH		6.2	8.0	8.6
Total dissolved solids	mg/L	400	3,400	22,800
Chloride	mg/L	11	490	4,900
Sulfate	mg/L	15	1,788	12,000
Hardness	mg/L	68	1,110	3,300
Selenium	μg/l	< 1	47	2,812
Arsenic	μg/l	< 1	2	63
Boron	mg/L	< 0.05	5.6	61
Molybdenum	μg/l	< 5	17	724

SOURCE:

CVRWQCB 1988.

Table 25. Physical and Chemical Characteristics of Tile Drainage

When the CVP's San Luis Unit was authorized in 1960, it included facilities not only to deliver water to irrigators, but also to remove drainage water from the San Joaquin Valley. The San Luis Drain would have conveyed agricultural wastewaters to the western Delta for disposal. Portions of the drain were built in the San Joaquin Valley during the 1960s and 1970s, but construction of the final section to the Delta was delayed pending resolution of questions regarding potential environmental consequences. The U.S. Bureau of Reclamation decided to construct Kesterson Reservoir to store and evaporate drainage water until the linkage to the Delta could be completed.

In 1983, deformities and deaths of aquatic birds at Kesterson Reservoir were discovered and attributed to selenium poisoning. The discharge of subsurface drainage to Kesterson Reservoir was halted and feeder drains to the San Luis Canal were plugged. This episode also altered perceptions of the drainage problem and virtually eliminated the concept of completing a drain to the Delta. Currently, lands remain undrained, excess drainage water makes its way by various routes to the San Joaquin River, or it is collected and stored in local evaporation ponds. Unless an alternative management strategy for disposal of drainage waters can be found, waterlogging and salinization of land can be expected to continue and worsen. It is estimated that by 2040 about 180,000 acres of land in the San Joaquin Valley would be abandoned by agriculture unless a solution is implemented (Reclamation and California Resources Agency 1990).

The Central Valley WQCP recently was amended to include more specific provisions to curb the discharge to surface waters of toxic trace elements in subsurface agricultural drainage water. Although subsurface drainage often contains elevated concentrations of arsenic, boron, and molybdenum, the provisions focus on control of selenium. The plan prohibits new discharges of subsurface drainage water to the San Joaquin River and its tributaries, sets a maximum acceptable selenium emission rate to the San Joaquin River, and prohibits all discharges of subsurface drainage water to certain river reaches after 2010. These requirements would be reviewed periodically because of uncertainties regarding technologies for selenium control. The plan does not include any restrictions on the discharge of salts in subsurface drainage water.

Various technologies for desalting and removing selenium from drainage water have been investigated. Treatment technology for removal of salt from drainage water is available, but is far too expensive for practical application. Selenium removal technologies that have advanced beyond bench-scale testing include treatment using anaerobic bacteria, high-rate algal ponds, and ferrous hydroxide treatment. Even if proved feasible on a large scale, it is likely that these technologies would be relatively expensive and not easily incorporated into the agricultural economy. Other options for reducing discharges of subsurface drainage water containing high concentrations of salts and selenium include source control by better management of irrigation systems and practices, reuse of drainage water on salt-tolerant crops (including trees), evaporation of drainage water in ponds, pumping of the shallow aquifer to reduce groundwater levels, and modification of water pricing to include a drainage contribution surcharge. Discharges of salt and selenium could be reduced by retirement of land from agriculture, but this would probably be only marginally practical for selenium control because of the existence of selenium "hot spots" in some areas.

Some control measures involve construction of treatment facilities and ponds. These facilities would be built on land currently used for agriculture. Sediment may be emitted during and immediately following construction, but probably at rates no greater than that from the agricultural lands replaced by the new facilities. Another possibility would be to reduce the adverse impact of discharge of selenium and salts on water quality by timing the discharge to coincide with high flow periods. This would require the construction of large holding basins which could retain agricultural subsurface drainage during the summer and fall and release it in the winter and spring. It would, of course, only affect the concentrations of selenium and salts in receiving waters; total basinwide loads would remain the same.

Too many uncertainties are involved with the implementation of this action for comparisons to the existing condition or No Action Alternative to have any meaning or value. Thus, it is difficult to predict the what the condition of the western San Joaquin Valley will be in 2020. If a drain discharging outside the valley is built, or if the plan developed by the San Joaquin Valley Drainage Program is implemented, the acreage of irrigated agriculture in the valley would be likely to remain much as it is today. Emissions of salt, selenium, and other toxic trace elements to the San Joaquin River and its tributaries would be greatly reduced. However, if no solution is found to the drainage problems in the San Joaquin Valley, then large areas of land will be abandoned by agriculture. Again, the discharge of salts, selenium, and other trace toxic elements in subsurface drainage water would be reduced. Thus, it appears that all likely scenarios lead to a reduction in discharge of salts and toxic substances.

If a drain discharging outside the valley was built (for example to the ocean), this action may not be necessary. If the San Joaquin Valley Program Plan was implemented, or if no solution to the drainage problem was found, this action likely would produce some reduction in salt and selenium emissions compared to those that would occur without the action.

Relocate Diversions To Improve Water Supply Quality

Delta diversions could be relocated to improve water quality. Ways in which this could be accomplished are described for the Delta region in the Delta section.

Relocation of diversions in the Delta would potentially benefit agricultural users because a substantial proportion of the irrigation water supply used in the San Joaquin Valley originates in the Delta. However, Delta water is not a significant source of municipal water supply in the San Joaquin Valley.

There would be no short-term adverse impacts of this action. All construction activities would take place outside the San Joaquin River Region.

This action would result in an improvement in the quality of water diverted for agricultural water supply at certain times. The benefits would be greatest during periods of low Delta outflow when brackish water from San Francisco Bay penetrates into the Delta and increases the salinity content of diverted water. The reduction in salinity would lower the risk of damage to salt-sensitive crops and reduce the overall mass of salt applied to the land in the San Joaquin Valley. This would reduce the rate at which saline agricultural wastewaters build up in the valley. The long-standing drainage problem is described under the previous action.

Upstream Surface Water Storage South of the Delta in the San Joaquin Valley

Upstream storage south of the Delta would be filled with water during periods of high streamflow, usually in spring. Water would be released to the San Joaquin River or to satisfy irrigation demands during low-flow periods, usually in late summer or fall. The alternatives contain from 0 to 500 TAF of upstream surface water storage south of the Delta. Impacts would be similar to surface water storage projects north of the Delta (see the discussion for the Sacramento River Region).

Conveyance Components South of the Delta

Conveyance components south of the Delta include expansion of the Delta Mendota Canal and construction of a new Mid-Valley Canal, which would convey water to groundwater storage areas in the southern San Joaquin Valley. The conveyance components include new or expanded canals with capacities of 500 to 5,000 cfs.

Impacts would be the same as those described for conveyance components north of the Delta, except that no tunneling would be required. Impacts cannot be separated from the impacts of the alternatives.

Off-Aqueduct Storage South of the Delta

Off-aqueduct storage would be filled with water pumped from the California Aqueduct or the Delta Mendota Canal. When abundant water is available in the Delta, Delta pumping plants would be operated to convey water into storage via the two canals. Water would be released to the California Aqueduct and the Delta Mendota Canal to satisfy water demands during low-flow periods when restrictions on pumping were in effect. The alternatives contain from 0 to 2 MAF of off-aqueduct surface water storage south of the Delta.

The changes in water quality that result from water storage in off-aqueduct reservoirs would be similar to those described for upstream surface water storage projects. Changes in water quality downstream of off-aqueduct reservoirs would be different from those of upstream surface storage. All proposed sites for off-aqueduct storage are in arid lands on the east side of the San Joaquin Valley. They would be located in the watersheds of small ephemeral streams. Water would be conveyed from the reservoirs to the California Aqueduct or the Delta Mendota Canal by pipeline or by a constructed or natural channels. If water was conveyed in a natural channel, a new coolwater stream would be created where one does not currently exist. Water quality in the stream would be good. Some streambank erosion would be expected to occur as a result of increased stream flows, but at a rate that would not appreciably increase TSS content.

Off-aqueduct reservoirs may improve the quality of water conveyed to users in the SWP and CVP Service Areas Outside the Central Valley by reducing the need to pump from the Delta when water quality at the pumps is less than desirable. Concentrations of salt and THM precursers may be reduced.

Groundwater Storage South of the Delta

Groundwater storage south of the Delta in the San Joaquin Valley and the Mojave River Basin would be used conjunctively with surface waters to meet various needs and demands for water. During high-streamflow periods, groundwater aquifers with available space would be recharged with excess surface water, using spreading basins or injection wells. Water would be pumped from the aquifers to meet demands during low-streamflow periods.

The alternatives contain up to 500 TAF of groundwater storage south of the Delta. Impacts would be the same as for groundwater storage north of the Delta (see the Sacramento River Region).

SWP AND CVP SERVICE AREAS OUTSIDE THE CENTRAL VALLEY

<u>ALL ALTERNATIVES</u>

Water Quality Program, Including Coordinated Watershed Management

Relocate Diversions To Improve Water Supply Quality

The diversion relocation action in the Delta Region describes ways in which the water supply intakes in the Delta could be relocated to improve drinking water quality. Within the SWP and CVP Service Areas Outside the Central Valley, a number of communities receive water from the Delta and would potentially benefit from this action. Users of Delta waters outside the Central Valley drainage include communities in San Luis Obispo, Santa Barbara, and San Diego counties, and in the Los Angeles basin.

This action would result in an improvement in the quality of water diverted for municipal supply at certain times. The benefits would be greatest during periods of low Delta outflows when brackish water from San Francisco Bay penetrates into the Delta and increases the salinity and bromide content of diverted water. The reduction in salinity would not be expected to have much effect on the health of consumers, although it could benefit some individuals on low-salt diets. It might improve the palatability of water to some consumers but probably would not be noticeable to most. The reduction in bromide concentration would in turn reduce the concentration of THMs in finished water with possible health benefits to consumers.

Improve Finished Drinking Water Quality by Treating Raw Water To Reduce Concentrations of Total Organic Carbon, Pathogenic Organisms, Turbidity, and Bromides

As discussed under the Bay Region, Delta water has always been regarded by water purveyors as a less satisfactory source of drinking water supply than waters obtained from streams in the Sierra Nevada and its foothills. The quality of Delta waters could be improved by additional treatment.

Users of Delta water outside the Central Valley drainage include communities in San Luis Obispo, Santa Barbara, and San Diego counties, and in the Los Angeles basin.

The only short-term adverse impacts of this action would be those associated with the construction of new treatment units at existing water treatment plants. Minor and local increases in sediment discharge could occur at construction sites but they would be reduced by the application of conventional construction impact mitigation measures.

There would be no long-term adverse impacts of this action on water quality compared to the No Action Alternative. However, this action would indirectly increase the cost of water to consumers within municipalities served by the SWP and the CVP. This could alter patterns of water use, which could have indirect impacts on a number of environmental elements. Effects would be small in most cases because water costs are low compared to other costs incurred by residents and owners of businesses.

Comparison of CALFED Alternatives to Existing Conditions

If the Water Use Efficiency Program could be immediately implemented, average annual withdrawal rates of water from the Delta by the Projects could decrease by 5 to 10% compared to existing conditions (5.9 to 6.9 MAF currently are diverted by the CVP and the SWP) or, the water could be used for other purposes. If left in the system, the reduction in withdrawals by 300 to 690 TAF/yr would result in slightly improved Delta water quality in normal years, and considerably improved water quality in dry and critical years. It should be recognized, however, that this scenario could not occur. The Water Use Efficiency Program would require many years to take effect. In reality, withdrawals from the Delta would not be reduced; probably only the rate of increase in withdrawals would be reduced.

Changes in flows may indirectly affect water quality. The salinity/flow relationship at Vernalis may be affected by upstream salinity management. A barrier at the head of Old River would most likely reduce the export salinity because more of the San Joaquin River salt load will be transported out of the Delta. River flows may be used to estimate dilution indices for evaluating toxicity effects.

MITIGATION STRATEGIES

Ecosystem Restoration Program

CREATING WETLANDS AND AQUATIC HABITAT

Adverse effects on turbidity could be reduced by allowing vegetation to become established on the new levee before breaching the existing levees.

To avoid the release of toxicants from dredged materials placed directly into open water, only uncontaminated dredged materials should be used.

RECONTOURING AND REGRADING STREAM CHANNELS

Adverse impacts from recontouring and regrading of stream channels could be limited by excavating behind cofferdams and diverting flow around excavations.

REPLACING GRAVEL

When gravel is stockpiled at locations where it would be carried into stream channels, it should be prewashed to remove fine sands and silts. This mitigation measure would reduce the effects on instream water quality. Also, the risk of release of toxic materials in sediments could be reduced by testing and removal of sediments with high concentrations of chemical contaminants.

Water Quality Program, Including Coordinated Watershed Management

The relatively minor environmental impacts of construction activities at wastewater treatment plants could be further reduced by incorporating commonly applied construction mitigation measures, including erosion control measures (to prevent the discharge of sediment from disturbed land) and proper storage and handling of fuel and construction materials.

REDUCING POLLUTANT CONCENTRATIONS IN RUNOFF

Pollutant concentrations in runoff from cropland could be reduced in several ways. Soil erosion and the discharge of sediment to waterways could be reduced by changes in cultivation practices that make land less vulnerable to erosion, including no-till cultivation, allowing crop residues to remain on the soil surface, and contour plowing. Nutrient and pesticide loads could be reduced by adopting improved management practices that limit the application of fertilizers and pesticides to the minimum necessary to promote healthy growth of crops.

Tailwater recovery may be implemented primarily as a means of increasing water use efficiency, but it also would decrease pollutant emissions. Irrigation water that drains from croplands and would otherwise flow back to a stream is routed to a settling pond instead. A portion of the supernatant in the pond is recycled back to the head of the irrigation system and reused. Accumulated sludge in the pond is periodically removed and spread on cropland. The use of tailwater recovery would significantly reduce the mass emission of suspended solids and organic matter in tailwater and probably also would result in a reduction in nutrient and pesticide emissions. Some of the nutrients and pesticides probably would be associated with particulate material and would be retained in the settling pond. Complete recycling of tailwater is not possible, because salt concentrations would build up and crops would be damaged if a portion of the tailwater was not removed from the system. Consequently, tailwater recovery does not result in a reduction in salt emissions. Because tailwater recovery reduces the volume of water returned to streams, the concentrations of salts in tailwater would be increased. Concentrations of nutrients and pesticides in tailwater also may increase, although concentrations of suspended solids likely would remain the same or decrease.

Emission of suspended solids from rangeland can be controlled using grazing management practices that maintain at least some vegetative cover on the ground surface and exclude domestic animals from stream channels. Unlike runoff from cropland or rangeland, runoff from confined animal feeding operations is often a strong waste stream. It usually must be collected and treated or disposed on land.

Levee System Integrity Program

MINIMIZING EFFECTS OF LEVEE CONSTRUCTION

Metals associated with sediments may be resuspended, and some portion of the metals may be dissolved during levee construction. Measures to minimize adverse effects associated with levee construction could include preproject assessment and planning; and preproject and post-project water, sediment, and toxicity monitoring. Based on these data and the mitigation measures envisioned, the anticipated resuspension of sediments and associated chemicals from levee construction operations should not pose significant water quality problems.

Activities conducted as part of the Levee System Integrity Program may require importing soils for engineering purposes. Depending on the source, these soils may contain metals that could be leached from the soils into Delta waters. Sediment guidelines for this type of material were developed by the SFRWQCB for upland use and wetland creation. These, and other guidelines, would be used to ensure that contaminated soils are not used for levee work.

Storage and Conveyance

CONSTRUCTING CONVEYANCE CANALS

If canals were expanded by construction of setback levees and abandonment of the existing levees, in-water construction activities could be minimized. Mitigation measures discussed previously would be used to control erosion associated with construction of canals.

CONSTRUCTING DAMS

Excess sediment could be discharged to streams as a result of construction activities directly in streams, and as a result of precipitation falling on exposed soils. Construction of dams and related facilities would occur almost completely in dry conditions. When a dam is built on a stream, the stream typically would be diverted around the active construction area. Also, for practical reasons, much of the ground-disturbing earthwork would be scheduled for the dry season. Increased rates of soil erosion are likely to occur during the rainy season in areas that have been disturbed by construction. The increase can be limited by various construction mitigation measures, including grading to avoid concentration of water flow, using silt fences and hay bales to slow and filter stormwater runoff, and revegetating disturbed soil surfaces.

DISPOSING OF TUNNELING MATERIALS

The disposal of tunneling materials could have implications for water quality. Broken rock obtained from subsurface strata may contain metals that can be mobilized when the rocks come into contact with precipitation. Metals could then drain to streams and rivers just as they do from abandoned mining sites. The risk of contamination from this source could be reduced by testing the materials and requiring special disposal procedures if there is a potential for water pollution. Special disposal procedures might include depositing materials away from watercourses and covering materials to prevent infiltration of precipitation.

POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

No potentially significant and unavoidable impacts on water quality are associated with CALFED actions.

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